POWER

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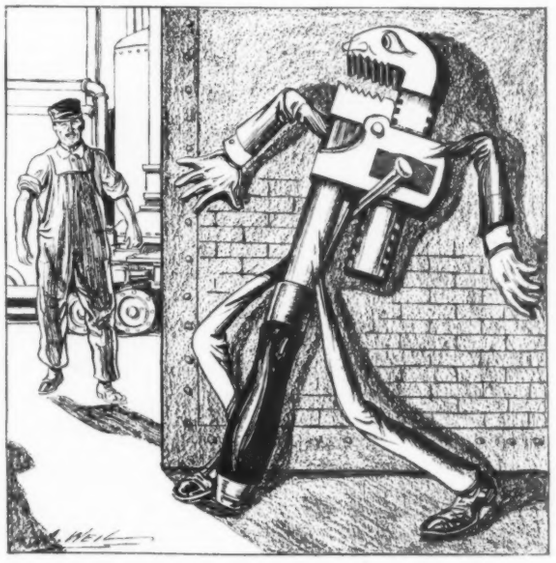
A FABLE!

Once upon a time, as a pipe wrench hung on a board with an assortment of solid wrenches, it addressed them as follows:



"Why is it that you are always kept so bright and shining? You hang here day after day and do nothing. If the engineer has a job of work to do, he must take your entire family in order to find one that will fit. Now look at me. I can take down a whole piping system; I can unscrew the piston rods of the engines; and besides this I am called upon to remove all sizes of stubborn nuts. It is readily seen that I am the most important tool on the premises.

"There! The new chief and his assistant are going to replace that pump gasket that blew out. See if it is not I that shall be called upon to do the work. His-s-t! The assistant is coming for me now. So long!"

"Mr. Findlay," said the chief, indignantly, "do you always use a pipe wrench to handle machine nuts? Half the nuts in this plant are so chewed up that it is next to impossible to remove them at all. Give that thing to me."

"With that, the chief hurled the offending wrench toward the door of the repair shop. However, his aim was bad and the wrench struck a pump foundation, breaking a jaw.

"Now, Mr. Findlay," said he, somewhat more calmly, "get a file and dress up those nuts so that they can be turned with a wrench intended for that purpose; and while I have charge here, never bring a pipe wrench into the engine room for the purpose of turning a nut."

"Poor old wrench," he continued, as he held the broken parts of the wrench together, "I didn't mean to break your jaw. But, you are just like lots of people—splendid success at the work for which you were intended, but a terrible bungler when you attempt to fill a place for which you were never designed."

Contributed by LOE ADDY, *Newcomerstown, Ohio.*

Municipal Power Plant at Medicine Hat

By A. G. Christie*

SYNOPSIS—A combined electric power and water-pumping plant. Natural gas is burned in the furnaces of the four 400-hp. water-tube boilers. Three turbines, two of 700-kw. and one of 1,500-kw. capacity, comprise the generating units. The rates charged for electrical energy vary from 6c. per kw.-hr. for from 50 up to 100 kw.-hr. per month, to 1c. for 2,500 kw.-hr. per month. Discounts are allowed on charges amounting to over $100 per month of from 10 to 40 per cent.; from $500 to $1,000, 50 per cent.; and on amounts over $1,000, 60 per cent.

The first municipal electric plant at Medicine Hat, Canada, was started in 1911. Two gas engines of 200 hp. each were installed to drive alternators of 130-kw. capacity. The operation of these engines with natural gas was never entirely satisfactory. When the demand for electricity increased with the growth of the city, it was decided to abandon gas engines in favor of boilers and steam turbines.

About November, 1913, the new steam plant was put in operation. The plant first contained two 750-kw. turbines. A third unit of 1,500-kw. capacity was started in January, 1915. Plans have been prepared for future extensions to any desired ultimate capacity, which can be erected without disturbing the present equipment.

The plant at present is well situated neither with regard to distribution nor for switching service from the railroad. Consequently installation costs of equipment were high. The location has made advisable a high-tension transformer station of 1,000-kw. capacity and a transmission line to some of the more distant industrial plants.

The building is of red brick, and as no coal bunkers had to be installed, it is comparatively low, and the concrete roof is too near the boilers for convenience in working above them. The plant is a combined electric-power and water-pumping station and consists of boiler

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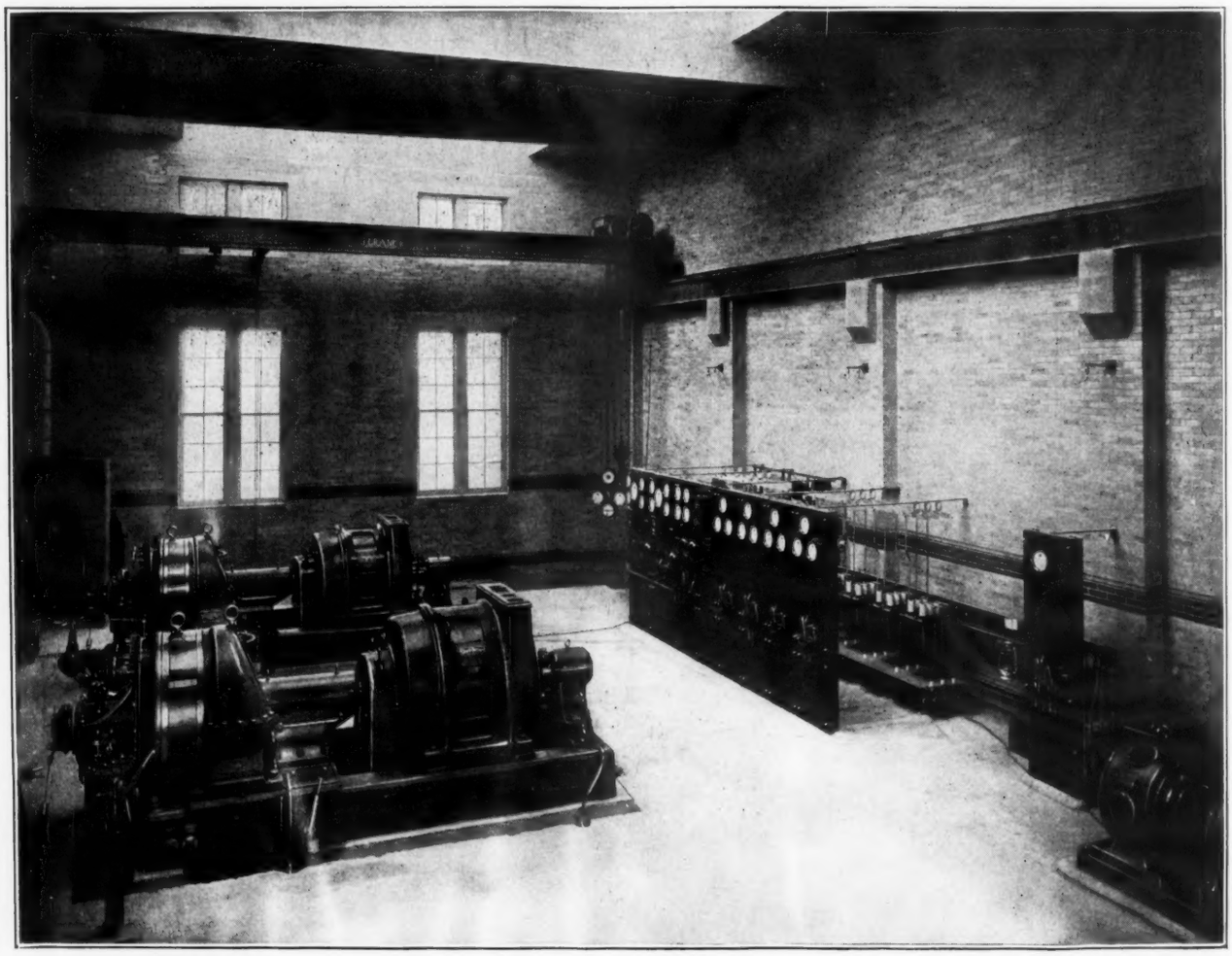


FIG. 1. PARTIAL VIEW OF THE TURBINE ROOM OF THE MEDICINE HAT MUNICIPAL POWER PLANT

room, steam-turbine room, pump room and water-filter room, as shown in plan in Fig. 5 and in the elevation cross-section in Fig. 6.

The fuel is natural gas from city-owned wells. It is said to have the following analysis: CH_4, 99.49 per cent.; H_2, 0.51 per cent.; O_2, trace; heating value, 1,100 B.t.u. per cu.ft.

The cost of development and production has been so low that a nominal charge of $1,000 a year is made against the electric plant to cover upkeep, depreciation and interest on the wells and pipe line to the plant.

The boiler room at present contains four water-tube boilers of 400-hp. capacity each, but without superheaters.

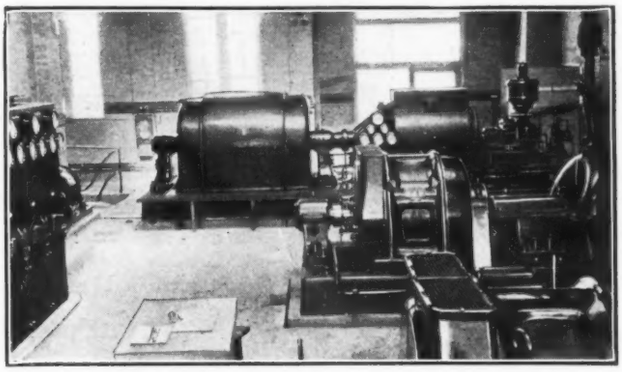


FIG. 2. NEW 1,500-KW. TURBINE-GENERATOR UNIT

Each boiler is fitted with fifteen 5-in. gas burners, as shown in Fig. 3. These play against a Mexican firebrick checkerwork, two bricks deep, inside the furnace. This mixes the gas and air and aids combustion. The gas is reduced to 6-oz. pressure in the header above the burners. The gas supply to the burners and the main boiler dampers are hand-controlled. It has been found by test that better results are obtained by lowering the burners until they are just above the firebricks covering the stationary grates. Consequently all burners are now being lowered, as shown in Fig. 4.

As no ash or smoke is produced, it has not been found necessary to blow off the tubes more than once in several months. At present the chief difficulty in connection with boiler operation is scale from the feed water.

The flue gases leave the boiler through an underground smoke flue to either of two induced-draft fans and are then delivered to a steel stack projecting a short distance above the roof. These fans were bought to handle twice the present boiler equipment and in consequence are now driven very slowly by the direct-connected vertical slide-valve engines. These engines have no automatic speed control at present. On account of the low cost of fuel, no economizers were installed.

Of the two feed pumps, one is a duplex outside-packed plunger pump and the other is a 4-in. two-stage centrifugal-pump turbine driven through a flexible coupling. Although it usually handles cold water from the filter beds when the large turbine is not in operation, it has been found that the impellers and casing scale up badly. The only explanation that has been offered for this phenomenon is that the centrifugal force resulting from the high speed causes a precipitation of the scale-forming salts from solution.

A spiral copper-coil closed heater has given so much trouble by clogging up with scale that it has been of little use and is very inefficient even though boiler compound is used in the feed water. It is proposed to install a metering open heater as soon as possible, to use the exhaust steam from the steam-driven auxiliaries.

Two duplicate feed lines, as required by the Boiler Rules of Alberta, made of 4-in. pipe, carry the water from the feed pumps to the boilers. The two feed connections to each boiler can be seen in Fig. 3. The plan and elevation of the gas and water piping are in Fig. 7.

The blowoff pipes from the boilers are each provided with a plug cock and an approved type of blowoff valve also, as required by the boiler rules. These discharge through a 45-deg. Y into the main blowoff pipe.

The main steam header, placed behind the boilers, consists of 10-in. pipe and contains two separators. The connections of 6-in. pipe from the boiler to the header consist of bends with a gate valve and an automatic nonreturn valve in each. The pipes to the turbines consist of bends and pass down under the floor of the turbine room, where they are also provided with separators. Two duplicate lines of 3-in. pipe connect to the fan engines, while another 3-in. line leads from the main header to the house pump in the turbine basement.

The first steam turbines installed were two of 750-kw. capacity each, at 3,600 r.p.m. The rotor carried a Curtis stage with two velocity rows on the high-pressure end, followed by three Rateau stages, each with a disk carrying a single row of blades. These disks are separated from each other and from the Curtis stage by diaphragms carrying the orifices and reaching to the shaft. The governor is built on the horizontal cross-shaft, which is

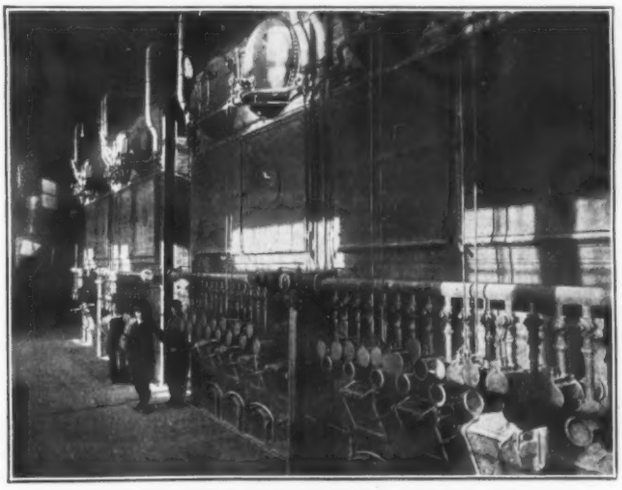


FIG. 3. FOUR 400-HP. WATER-TUBE BOILERS AND GAS BURNERS

driven by gears from the main spindle. It controls the main throttling valve by means of an oil relay. Two valves are also provided on the end of the upper half of the turbine casing. When the load approaches 700 kw., one of these is opened by hand and admits steam to additional nozzles. The other valve must be opened by hand when normal rated load is exceeded. Fig. 1 shows the turbine room before the large turbine was completed.

The generators on the two small turbines are of English design, with their fields wound for only 56 volts, which is unusual in American practice. Cooling air is drawn from outside and discharged into the turbine room. The machines are three-phase 2,300-volt alternators.

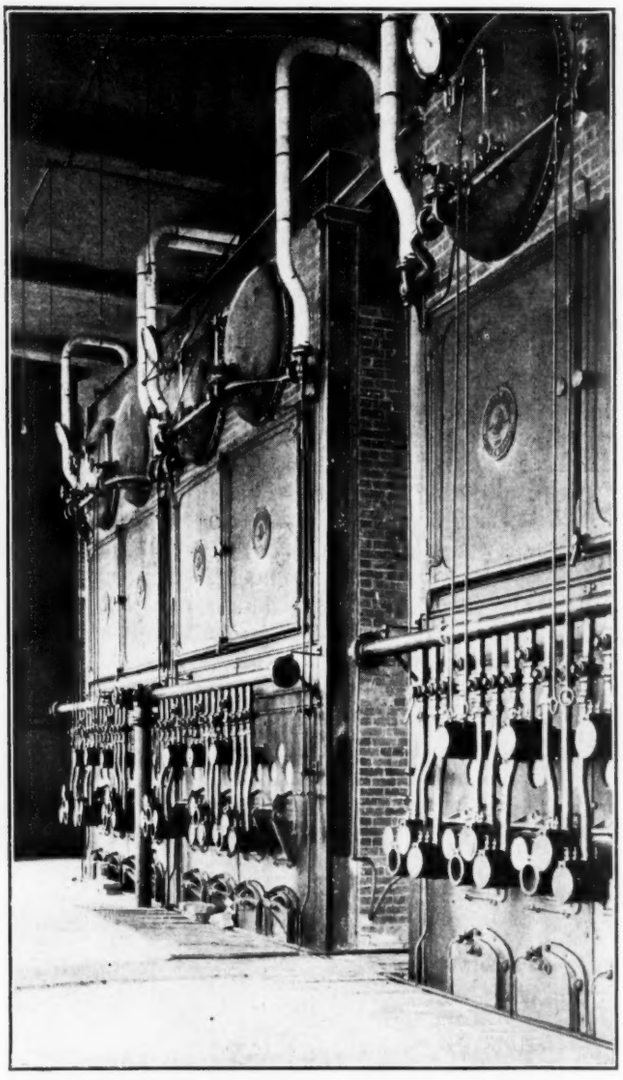


FIG. 4. NEW ARRANGEMENT OF GAS BURNERS

The newest turbine is of 1,500-kw. capacity at 3,600 r.p.m., with a Curtis ring on the high-pressure end of the spindle, shown in Fig. 2. Its overload valve is controlled automatically by the governor. The fields of the generator are also wound for 56 volts, so that it can be served by the exciters already in place.

Two exciter units are provided. One consists of a turbine directly connected to a 35-kw. direct-current generator that runs at 2,700 r.p.m. Since but 56 volts is produced, extra commutator surface had to be provided to handle the current. Two were built side by side along the shaft and connected by flexible copper strands between the two sets of bars which provides ample ventilation. The other exciter consists of a 2,300-volt induction motor driving a 50-kw. direct-current generator, also built with a double commutator.

The two small turbines exhaust to multi-jet ejector condensers placed in the basement under the exhaust nozzle and above a hotwell. Each condenser has two

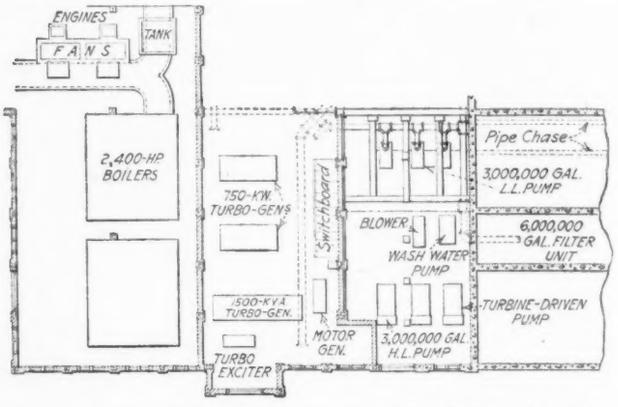


FIG. 5. PLAN OF PUMP AND WATER-FILTER ROOMS

centrifugal pumps driven by the same motor. One pump takes water from the low-service main and forces it through the ejector nozzles. The water from the hotwell can run back into the river through a sewer or, depending on the season of the year, can be discharged by the second pump into the sedimentation tanks for the city water-supply. The water in passing through the jet condensers picks up nothing but condensed steam containing no oil or grease. Hence, not being polluted or contaminated in any way, it is fit for domestic use.

The large turbine is equipped with a surface condenser, and the condensed steam is used for boiler-feed purposes. It is supplied with a set of pumps all on one shaft, driven by a single-wheel impulse turbine. This set consists of a centrifugal pump to handle the cooling water, another small centrifugal pump to remove the condensed steam and an air pump. This condenser produces better vacuum than the jet condensers.

When operating noncondensing, the turbines can exhaust into a 20-in. header placed in the turbine-room basement and led to the roof behind the boilers in the boiler room.

The switchboard is made of black slate (Fig. 1). The 2,300-volt busbars and all the oil switches are placed

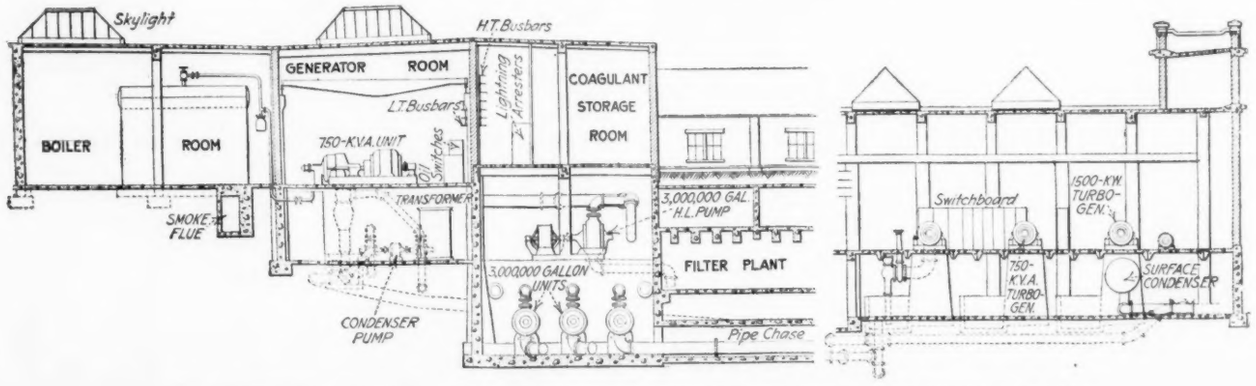


FIG. 6. ELEVATION AND CROSS-SECTION OF THE BOILER, PUMP AND TURBINE ROOMS

well behind and away from the board. The lightning arresters are on poles just outside the plant.

An interesting feature in plant operation is the use of 2,300-volt motors throughout the station. This necessitates a panel for switches, starting apparatus and meters. Many of the motors used by the city's customers are also for 2,300 volts, thus making transformers unnecessary.

Details of the Pumping Plant

The pump room of the water-pumping station for the city contains two sets of pumps—one for low lift and the other a high-lift set. Three single-stage centrifugal pumps driven by 50-hp. motors take water from an intake in the river. They are capable of delivering 3,000,000 gal. per day each, into a 20-in. discharge line, against a 20-lb. head. The condensers take their water from this line.

The water from these pumps passes into sedimentation tanks and treating tanks and then through sand filters. The resulting clear water is delivered to the city reservoir on the top of a neighboring hill, by either of three high-duty two-stage centrifugal pumps. Two of these are motor driven by 325-hp. induction motors; the third is a reserve for fire and is driven by a single-wheel impulse turbine of similar power. Each pump can deliver 3,000,000 gal. into the reservoir in 24 hr. The water-treating plant can be duplicated at any time without disturbing the present equipment.

The electrical plant and the pumping plant are under the same management. It is possible with the reservoir to regulate the pumping load so as to fill in the light-load periods of commercial service and thus increase the load factor of the plant.

The turbine room is provided with a 5-ton hand crane for construction and overhauling operations.

Costs of Operation and Rates for Service

The financial statement for Medicine Hat for 1914 shows the figures given in Table 1 for the total charges against the electrical plant. The plant records show that 3,050,700-kw. hr. were generated in 1914. The utility earned $49,251.08, and a surplus of $623.36 was transferred to the general funds. The revenue per kilowatt-hour generated was therefore 1.614 cents. The net cost of the electrical plant and distribution system was about $400,000.

TABLE 1. COSTS OF OPERATION, ETC., 1914

	Cost	Cost per Kw.-Hr., Cents
Operations, repairs and maintenance	$16,997.89	0.557
Salaries, bad debts, etc	3,728.66	0.121
Depreciation on tools	74.96	0.002
Debenture interest	14,821.95	0.486
Sinking Fund	13,004.26	0.426
Total	$48,627.72	1.592

There are two rates for lighting service. Private residential lighting is billed at the rate of 8c. per kw.-hr.

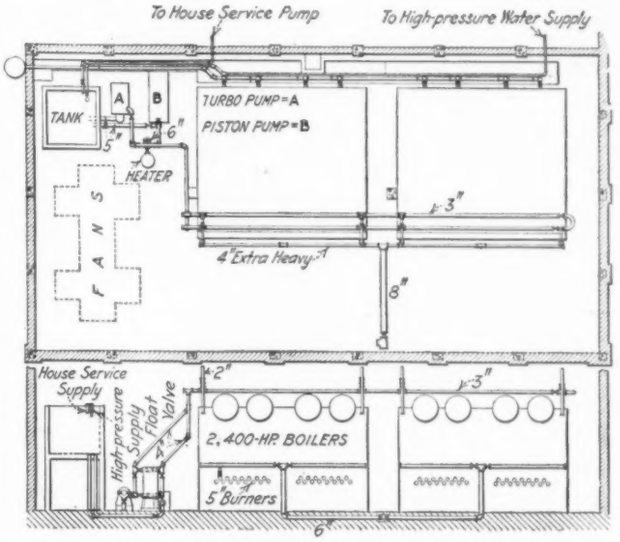


FIG. 7. PLAN AND ELEVATION OF GAS AND WATER PIPING

Business establishments pay 6c. per kw.-hr. for light. For prompt payment a discount of 10 per cent. is allowed on bills. The plant does no street lighting, for this is all furnished by inverted-mantle gas lamps. It has been found cheaper to allow these to burn all day than to pay attendants to turn them on and off. As gas is abundant, it is sold by the city for 15c. per 1,000 cu.ft. for domestic purposes.

PRINCIPAL EQUIPMENT OF MEDICINE HAT MUNICIPAL ELECTRIC POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Water-tube	400-hp	Generates saturated steam.	Fired with natural gas	Babcock & Wilcox Co.
2	Fans	Multivane		Produce induced draft	Engine-driven	Green Fuel Economizer Co.
1	Stack	Steel		Discharges flue gases	Receives discharge of fans	Green Fuel Economizer Co.
1	Pump	Duplex, outside packed	10x6x12-in	For boiler feed	Discharges water through heater	Platt Iron Works Co.
1	Pump	Two-stage centrifugal	4-in	For boiler feed	Turbine-driven, 2,900 r.p.m	Jeanesville Iron Works Co.
1	Turbine	Terry		Drives feed pump	Exhausts to heater	Terry Steam Turbine Co.
1	Heater	Closed tubular		Heats feed water	Uses all exhaust steam	
2	Turbines	Curtis-Rateau	750-kw	Drive generators	3,600 r.p.m., 4-stage	Frazer & Chalmers Co.
2	Generators	Turbo, alt	750-kv.-a	Produce power	Driven by turbines, three-phase, 2,300-volt	Siemens Bros.
1	Turbo-generator	Westinghouse, alt	1,500-kw	Generates power	3,600 r.p.m., three-phase, 2,300-volt	Westinghouse Machine Co.
2	Condensers	Ejector jet	750-kw	Condense steam	Direct-connected to Rateau turbines	Frazer & Chalmers Co.
2	Pumps	Centrifugal		Supply jet condensers	Two pumps per set, 900 r.p.m., motor-driven	Pumps—Drysdale Co. Motors—Siemens Bros.
1	Condenser	Surface	1,500-kw	Condenses steam from 1,500-kw. turbine		Westinghouse Machine Co.
1	Set condenser pumps	Leblanc air pump, Circulating pump, Hotwell pump, Turbine		With surface condenser	2,000 r.p.m., turbine driven	Westinghouse Machine Co.
1	Exciter	Direct-current	35-kw	Furnishes exciting current	2,700 r.p.m., 56-volt turbine driven	Siemens Bros.
1	Turbine	Terry	35-kw	Drives exciter	2,700 r.p.m	Terry Steam Turbine Co.
1	Exciter	Motor-generator	50-kw	Furnishes excitation	900 r.p.m., 56-volt d.-c	Siemens Bros.
1	Switchboard	Black-slate	9 panels	Main and distribution board	No high voltage on board	Siemens Bros.
2	Centrifugal-pumps	Two-stage	3,000,000 gal. per day.	City pumping units	1,200 r.p.m., 325-hp. induction motors	Motors—Siemens Bros. Pumps—Drysdale Co.
1	Centrifugal pump.	Two-stage	3,000,000 gal. per day.	City pumping unit	Turbine-driven	Pump—Mather & Platt Turbine — Westinghouse Machine Co.
3	Pumps	Centrifugal single-stage	3,000,000 gal. per day.	Low-lift pumps	50-hp. induction motors, 20 lb. total lift, serve condensers and filter beds	Motors—Siemens Bros. Pumps—Drysdale Co.
1	Crane	Hand traveling	5-ton	For construction		Whiting Foundry Equipment Co.

TABLE 2. COMMERCIAL POWER RATES

Consumption per Month, Kw.-Hr.	Rate per Kw.-Hr., Cents
50 up to 100	6
101 up to 250	5½
251 up to 450	5
451 up to 650	4½
651 up to 850	4
851 up to 1,050	3½
1,051 up to 2,000	3
2,001 up to 3,000	2½
3,001 up to 5,000	2
5,001 up to 25,000	1¼
25,001 upward	1

A minimum charge of $1 per month per hp. is made on single-phase motors. Three-phase motors from 3-hp. up have a minimum charge of 50c. per hp. per month.

TABLE 3. PROMPT-PAYMENT DISCOUNTS

Cost per Month	Discount, Per Cent.
For the first $100	None
For the second $100—excess over $100	10
For the third $100—excess over $200	20
For the fourth $100—excess over $300	30
For the fifth $100—excess over $400	40
From $500 to $1,000—excess over $500	50
Excess over $1,000	60

The main output is the commercial load, and hence the figures in Table 2 are of considerable interest. These are the base rates on which the prompt-payment discounts shown in Table 3 are allowed. When electricity is used in large quantities, this plant provides cheap power.

An excellent system of plant records has been introduced and has stimulated the interest of the operating force in the economical production of power. Suitable offices and testing laboratories have been provided.

The general plans were made by R. S. Lea, of Montreal. Recent construction and operation has been in charge of G. R. Taylor, superintendent of the electric power department. Credit is due to him, and to the chief engineer, J. Rae, and his assistants for the information and drawings contained in this article.

Measuring Three-Phase Power by a Watt-Hour Meter

By A. L. Temple

SYNOPSIS—The action of the current and potential coils of an induction-type watt-hour meter is explained and diagrams are given for measuring the power in a three-phase circuit by either a single-phase or a polyphase watt-hour meter.

To understand the measurement of power by a watt-hour meter, it is essential that the relations in an alternating-current circuit be understood. In discussing current and voltage in alternating-current circuits there are three values sometimes referred to; these are the instantaneous value, average value and effective value. The instantaneous voltage, or current, is the value at any instant during a cycle. The average value for any half-cycle is equal to the average of the instantaneous values of that half-cycle, and the average value for a complete cycle is zero. The effective value equals the square root of the mean squares of all the instantaneous values for a cycle and is that value of current equivalent to a direct current that will produce the same heating effect in a plain resistance; this is the value as measured by ammeters and voltmeters.

The product of effective volts and effective amperes is the apparent power, or volt-amperes, and this product divided by 1,000 gives kilovolt-amperes, usually abbrev-

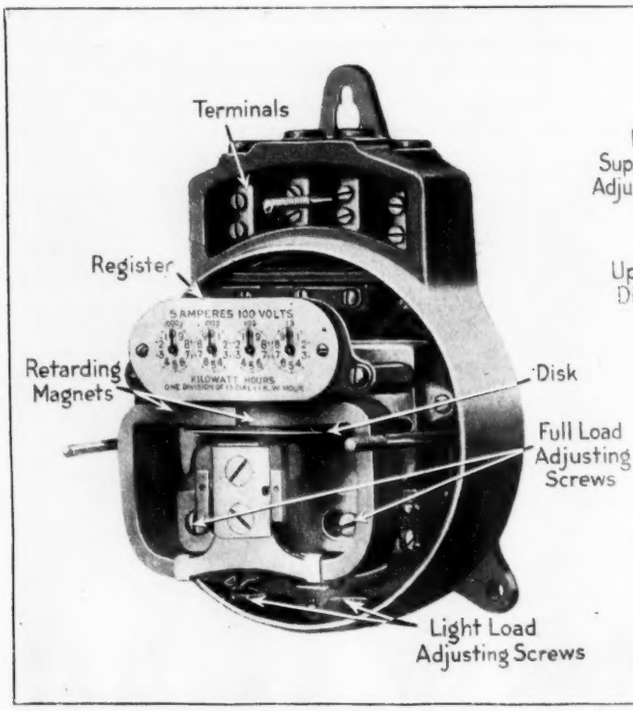


FIG. 1. SINGLE-PHASE INDUCTION TYPE WATT-HOUR METER

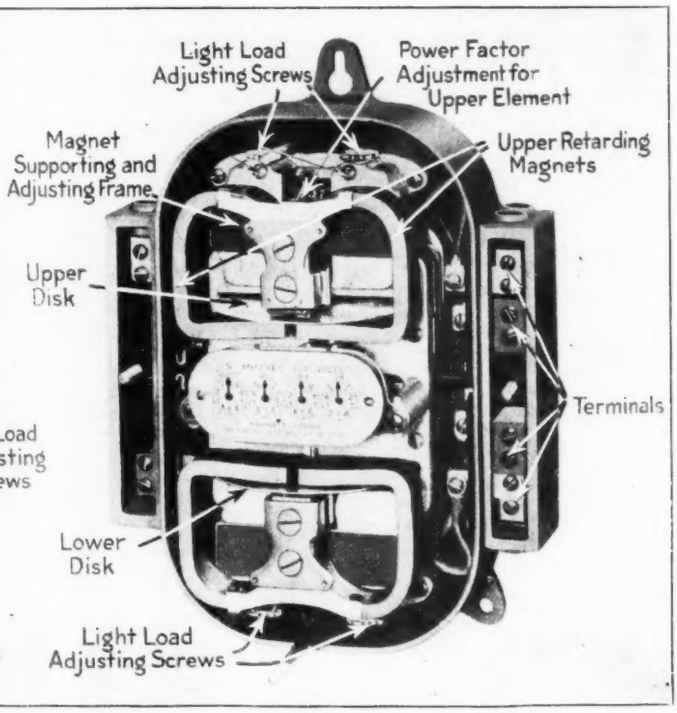


FIG. 2. THREE-PHASE INDUCTION TYPE WATT-HOUR METER

iated "kv.-a." The kilovolt-amperes obtained by multiplying the simultaneous readings of a voltmeter and an ammeter in any alternating-current circuit are equal to the watts consumed only when the current and voltage are exactly in phase, which is rarely the case when inductive apparatus, such as induction motors and transformers, is operated on the system. The formula for watts load on a circuit is expressed as follows:

For a single-phase circuit

$$Watts = Amperes \times volts \times cos\ \theta$$

For a three-phase circuit

$$Watts = \sqrt{3}\ amperes \times volts \times cos\ \theta$$

In this formula θ is the angle of lag between the current and the voltage and cos θ is a measure of the power factor, or the ratio of the actual watts to the product of volts and amperes. For a watt-hour meter to read watt-hours directly where the power factor may be any value, there must be some arrangement to take care of the power factor in the construction of the meter.

The induction type of watt-hour meter (see Fig. 1), which is the type most used on light and power circuits, consists of current and potential windings arranged in such a way that they produce a rotating field which cuts a closed-circuit secondary and causes it to rotate much in the same way as in the induction motor. The secondary usually consists of an aluminum disk mounted on jewel bearings so as to rotate in the magnetic field and at the same time between the poles of permanent magnets which have a breaking effect. The series or current windings consist of two coils of a few turns of large-sized wire wound in opposite directions and connected in series with the main circuit. These coils are practically noninductive. The potential coils are impedance coils and are wound with a large number of turns of small wire arranged so as to produce a large phase displacement (practically 90 deg.) of the potential and current circuit fields. This arrangement provides that when the current in the current coils lags 90 deg. behind the voltage of the circuit, the field of the potential circuit lagging 90 deg. behind the impressed voltage by construction, then a condition is brought about such that there is no torque and the meter shows no power in the circuit according to the relation as expressed by the formula, watts = $\sqrt{3}$ amperes $\times$ volts $\times$ cos θ. When θ equals 90 deg., cos θ is zero and the right-hand side of the formula becomes zero, or a condition of no power is shown.

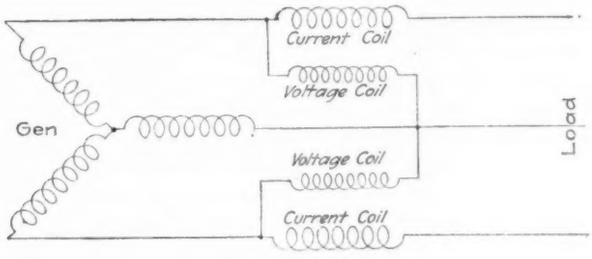


FIG. 3. ARRANGEMENT OF TWO SINGLE-PHASE METERS FOR MEASURING THREE-PHASE POWER

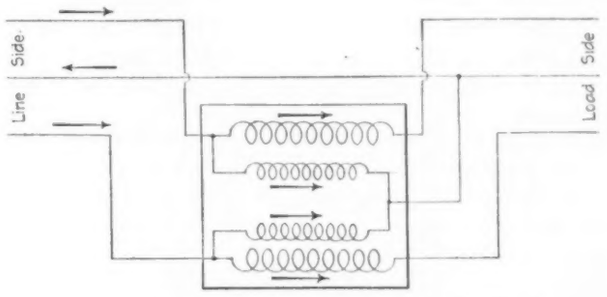


FIG. 4. CONNECTIONS FOR METER SHOWN IN FIG. 2, ON THREE-PHASE CIRCUIT

On the other hand, when the meter operates on a noninductive circuit, one in which the power factor is 100 per cent. as on a lamp circuit, the inductance of the circuit is zero and the current and voltage are in phase. The fields produced by the current and potential coils of the meter are then displaced 90 deg. and a maximum torque is produced. Thus for any other power factor between cos θ = 1 and 0, the interaction of the fields of the potential and current coils is such as to satisfy the formula through the production of a torque on the rotating element so as to cause a speed proportional to the power consumed. This speed is made faster or slower for calibration purposes by a magnetic brake consisting of permanent magnets that can be moved in or out from the center of the revolving disk. The breaking action is secured through eddy currents set up in the disk, and moving the magnets to the outer edge of the disk has a slowing-down effect, while moving to the center allows the disk to speed up.

This explains the action of the current and voltage coils in a watt-hour meter. The actual reading in kilowatts is made possible through a proper arrangement of gears, the number of revolutions of the disk shaft driving them being proportional to the total power taken from the circuit whether the demand is varying or constant.

On account of the current and voltage relations in a three-phase three-wire circuit, it can be shown mathe-

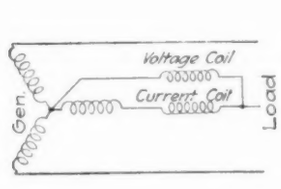


Fig. 5

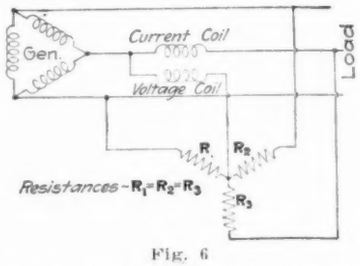


Fig. 6

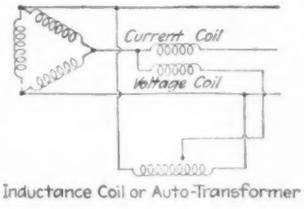


Fig. 7

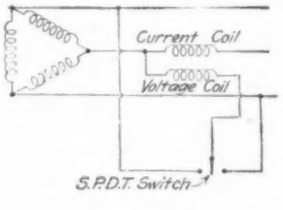


Fig. 8

FIGS. 5 TO 8. SHOWING VARIOUS CONNECTIONS FOR MEASURING THREE-PHASE POWER WITH A SINGLE-PHASE METER

On account of the current and voltage relations in a three-phase three-wire circuit, it can be shown mathe-

matically that two single-phase wattmeters will measure the total power under all conditions, and the total power is the algebraic sum of the readings of these two meters when one meter has its current coils connected in one of the phase wires with the current coils of the other connected in any other phase wire and each having the potential coils connected from the wire in which its current coils are connected to the third phase wire, as shown in Fig. 3. When the power factor is greater than 50 per cent. with this connection, the readings of the meters are added, and when less than 50 per cent., one meter will run backward and have a negative reading, so that the total power is obtained by subtracting the two readings. In the polyphase watt-hour meter used on three-phase circuits, the two single-phase meter elements are mounted one above the other on the same shaft and have but one set of registering dials, as shown in Fig. 2. The operation is the same as though two separate single-phase meters were connected as described, except that in the polyphase meter the adding or subtracting of the readings for any power factor is taken care of automatically from the fact that the two disks of the two elements are connected to the same shaft.

Briefly, the reason for only two current elements and two voltage elements in two phases of a three-phase circuit to register the total power can be stated as follows: In any three-phase three-wire system the current in one wire is at any instant equal to the algebraic sum of the currents in the other two wires; in other words, one wire is the common return for the other two.

When a three-phase circuit is perfectly balanced the total power can be measured by one single-phase wattmeter, as shown in the connections of Figs. 5, 6, 7 and 8. In Figs. 5 and 6, the meter registers one-third the total power, and in Figs. 7 and 8 one-half the total power. In either case the values are correct for any power factor so long as the circuit is balanced. Since most commercial circuits are not balanced or may vary in balance from time to time, these connections are not accurate and should be used only for approximating the power demand and not for charging for service.

Instead of the three equal resistances used to form an artificial neutral, as in Fig. 6, a Y-box can be used, made up of two equal noninductive resistances connected in series with the two ends and junction point connected to binding posts. The resistances should each equal the resistance of the potential coils of the watt-hour meter, so that one terminal of the potential circuit of the wattmeter can be connected to the junction point of the Y-box and the other terminal to the line wire in which the current coil is connected. The other two binding posts of the Y-box are then connected to the other two line wires. In this case the watt-hour meter will measure one-third the power taken from the circuit.

Will Quizz, Jr.

SYNOPSIS—Chief Teller leads into a discussion of the Pitot tube, the present use of which is increasing since the introduction into general use of practical flow meters, for various gases as well as liquids, based on this principle.

"You have noticed when you draw water from a pipe line that the pressure, shown by a gage near the outlet, is apt to drop considerably. What does that drop in pressure suggest to your mind, Will?"

"Why, it is energy lost by friction in the pipe, Chief."

"Steady, Will! Is it all lost in friction, or is part of it still present in the form of kinetic energy or velocity? Is it not energy transformed?

"A heavy weight suspended at an elevation exerts a certain strain by its weight on the line holding it, but if allowed to lower at a comparatively slow rate the tension on the line will be slightly less, and if lowered at the rate due to the action of gravity (as fast as it will go) the tension on the line will, except for the line friction, be zero. The same applies to water or anything else in motion in a pipe. When the end of the pipe is closed and there is no flow the gage shows the pressure, which may be resolved into static head, or the number of feet of water there is above the gage. When the pipe end is open there may be the same head, but the gage shows less pressure. Some of the static head is lost in overcoming friction, but if the pipe was perfectly smooth and there was no friction there would still be a difference in the pressure proportional to the velocity as in the case of the weight. The friction loss is variable and difficult to measure, but the velocity is determined by the use of a Pitot tube. The difference between the static head at no flow and the 'velocity head' at a given flow is termed the 'friction head.'"

"Wise me up on this Pitot-tube arrangement, will you, Chief? I notice you pronounce it 'Pe-tow.'"

"It is a device invented in 1732 by Henri Pitot, a French physicist and engineer. To get the idea, suppose one pressure gage connected in the ordinary way and another with its small connecting tube extended inside of the pipe and its open end curved so as to face against the flow. The first (No. 1) one would show a lower pressure when the flow was rapid, as stated before, but the second (No. 2) would show less difference under various conditions of flow, because some of the water which had gained velocity would expend its velocity again on entering or bombarding the opened end of the gage tube in its path.

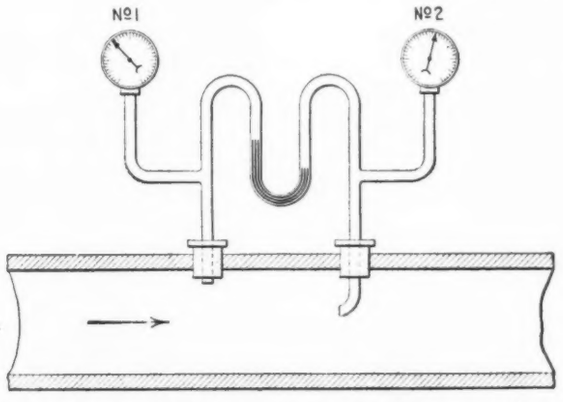
"By observing the pressure at no flow and the difference in reading by gages Nos. 1 and 2 at a given flow, the static head, the friction head and the velocity head may be known. Static head requires no further explanation. The friction head is the difference between the static head at no flow and the pressure shown by No. 2 gage (with the Pitot tube) at a given flow. The difference in pressure shown by No. 2 and the lower pressure shown by No. 1 during flow, when multiplied by the constant for that particular tube gives the velocity of the flow. The use of two gages would require that the pressure on each be noted and the difference obtained. The ordinary contrivance is simply a U-tube with one side connected to the wall of the pipe, as gage No. 1 just referred to, and the other side extended inside of the pipe as described in the second case No. 2. The

fluid in the U-tube will then show the difference in pressure on the two sides without the necessity of subtracting, just as the draft gage shows the difference in the air pressure on the inside and on the outside of the chimney or furnace or at two different points.

"The (pounds) difference in pressure in measuring water is resolved into feet head by the same process we have used before, that is, pounds, multiplied by 2.3, gives feet head (and feed head multiplied by 0.434 gives pounds pressure) as close as can be determined without going into more decimal places and the temperature of the water and other refinements not necessary to the general understanding of the principle of the Pitot tube."

"Then how is the velocity determined?"

"The operation involves principles which are simple enough when you look into them a little. The expression 'acceleration due to gravity' sounds formidable, but means simply how much faster a falling weight will be going at the end of each successive second than at the end of the previous one. A difference of pressure of one pound bears the same relation to velocity as if the water had fallen 2.3 ft. Suppose the pressure on gage



COMBINATION FORMING A DIFFERENTIAL MANOMETER

No. 1 showed, say 14 lb. less than that on No. 2 when the end of the pipe was open. This would be equal to a fall of $14 \times 2.3 = 32.2$ ft., which would be the distance the water would have to fall to get going at the same velocity as the water in the pipe. A weight of one pound falling freely is in the same condition as if a push or pull of one pound was continuously exerted upon it. It has been proved by numerous experiments that the speed acquired at the end of one second by a falling body starting from rest is 32.16 ft., and that each succeeding second during which it falls its velocity will increase at the same rate or, in other words, it will fall 32.16 ft. farther than during the preceding second.

"You are wondering, no doubt, what all this has to do with the question started with. Well, it's just this: Water falling through a pipe obeys the same law (keep in mind all the time that we are disregarding so far all the losses, friction included).

"If such a curved tube of uniform bore as has been referred to was placed in the current of a stream with its upper end slightly above the level of the water there would be a flow through the tube proportionate to the velocity of the stream, size of the tube and its elevation. The energy derived from the stream would be the weight of water multiplied by the elevation above the level of the stream or the familiar 'foot-pounds energy.'

"If the discharge end of the tube is elevated out of proportion to the stream's velocity, the flow of water from it ceases, but energy is being exerted at the lower end just the same, although its effect is displayed only in sustaining the column of water in the tube somewhat higher than the level of the water in the steam (this may be compared with the difference between directing a jet of water against the bucket of an impulse waterwheel or against a stone wall—the energy is the same but the effect is different).

Another Demonstration of the Principle

"Suppose the horizontal part of the tube was extended a short distance and turned upward under a waterfall. If extended upward to the crest of the fall the downstream end would show the level at which the water was received by the upstream end, of course. If, then, the vertical receiving pipe was shortened, and its open end fixed under the fall, then the level at the downstream end would indicate exactly the same as before (friction, etc., disregarded).

"All of this applies likewise to a fluid or gas in a closed channel or pipe, as the end of the Pitot tube in the pipe receives the impact of the flow, or velocity. With the U-tube connected as shown the static (no-flow) head balances the two sides, but when the flow starts the lowering on one side indicates the amount of static head being utilized, or converted into velocity. This difference in level is referred to as the velocity head. This instrument does not indicate the friction head as shown by the two pressure gages.

"Now for the allowance to be made in using the Pitot tube. Of course, it has some internal friction, but the greater allowance must be made for the fact that the momentum of the fluid is not entirely destroyed at the tube end, nor is the total energy of the jet realized at the bucket of the waterwheel, otherwise it would show a 100-per cent. efficiency. Therefore, a tube of this kind must be calibrated, or tested, to meet the particular service for which it is intended. This is done by observing its characteristics when exposed to a flow of known velocity or by propelling the tube through still water at a known rate of speed per minute or second."

"Then, I suppose, Chief, each instrument must be tested and compared with some standard, like thermometers are compared with one known to be correct."

Tubes Must Be Tested and Standardized

"Yes, the shape of the tube end will influence the action. A bell mouth will absorb more of the energy of the velocity than a contracted end, but the latter form is more commonly used as it causes less disturbance in the stream, and with the proper constant, or coefficient, is as reliable as any other form; but you must know what the coefficient is for a given tube. The most convenient constant for general use is 50 per cent. or, in other words, one-half the theoretical velocity.

"Going back to the falling-body story then, a *head* or fall to produce a certain velocity is equal to the velocity squared (multiplied by itself) and divided by g the velocity attained in one second, or 32.16 ft. When the head or fall is known (the difference in pressure by the gages resolved into feet as before stated) the *velocity* is determined by multiplying the 32.16 by the head in feet and by the constant for the instrument (here is where

the 50-per cent. comes in handy—you simply multiply the result by 2) and extract the square root. The formula is more easily remembered. For the theoretical conditions

$$h = \frac{v^2}{g}, \text{ or } v^2 = gh, \text{ and } v = \sqrt{gh}$$

but with the coefficient applied it becomes

$$h = \frac{cv^2}{g}, \text{ or } v^2 = \frac{gh}{c}, \text{ and } v = \frac{\sqrt{gh}}{c}$$

when

g = 32.16 or velocity due to gravitation;
h = Head in feet;
v = Velocity in feet per second;
c = Constant, or per cent. of theoretical velocity, commonly 50.

"Suppose the difference in pressure is 4 lb. on an instrument calibrated at 50 per cent., or about 9 ft., then the velocity would be the square root of

$$9 \times 32.16 \times 2 = \sqrt{578.88} = 24.06 \textit{ ft. per second}$$

"If the instrument was calibrated at 70 per cent., then with the same gage reading the velocity indicated would be $9 \times 32.16 \div 0.70 = \sqrt{413.5} = 20.34$."

"Chief, I did not get as far as square and cube root before I had to leave school."

"That's too bad, Will, but you must make up that deficiency by study now, before you can go far in the necessary engineering calculations. In this case, however, you can get the result by a 'trial-and-error' method. See what number multiplied by itself will give 578.88. Twenty-four will be pretty close. Better get at your studies of formulas too, so that a theorem can be more easily explained or set forth to you. It saves a lot of words and time when you get accustomed to using signs and formulas."

Morse Shaking-Dumping Grate

The Morse shaking and dumping grate bars, Fig. 1, are constructed with two trusses which run lengthwise, having curved and grooved clips bridged crosswise, each clip forming a double brace with the trusses. The curved clips allow for expansion and contraction and relieve the trusses from warping and buckling strains. A ¼-in. channel is provided, which runs the length of each clip so as to allow ashes to lie in the channel and prevent the metal from fusing and to also act as a nonconductor of heat to the metal.

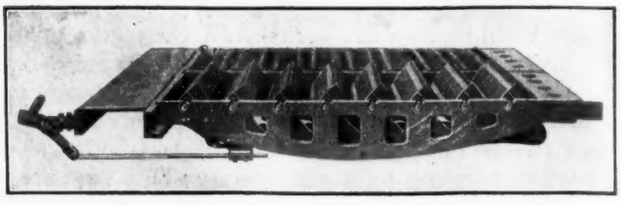


FIG. 1. BARS IN RUNNING AND DUMPING POSITION

The trusses, Fig. 2, are tapered from ⅞ in. on the top side to ⅜ in. at the under side. The clips are $\frac{9}{16}$ in. on the face side of the bar and are beveled to $\frac{3}{16}$ in. at the under side, Fig. 3. The distance between the clips on the face of the bar is ½ in., and on the under side it is ⅞ in. This bevel construction has the advantage of freely passing to the ashpit all ashes after they have passed through the top openings in the grate, and owing to the tapered opening between the clips a large volume of air can pass through them to the fuel bed with but slight friction, which can hardly begin much before it

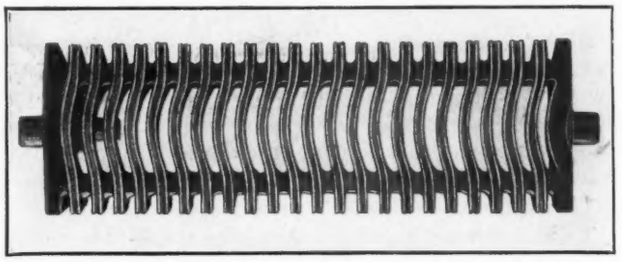


FIG. 2. FACE OF CURVED AND GROOVED CLIPS

reaches the extreme top edge of the face of the bar. The design of grate gives an air supply resembling a forced draft, as the volume of air gathered in the large spaces on the under side of the grate cannot escape except through the top side. The grate bars rest in the supporting frame on chilled axles. The frame is constructed without bolts, all parts interlocking.

A shaking and dumping lever head is attached to the boiler front for each section of grate. A rod is connected from it to the arm connecting with the individual shaking arms of the grate bars. Pressing the lever downward moves the bottom of the lever head in, which motion moves the connecting-rod of the grate bars toward the bridge-wall and turns them to the dumping position, shown in the foreground of Fig. 1. They are then separated about four inches. An extreme movement in the opposite direction brings the grates to the firing position, shown at the rear of Fig. 1. The shaking movement is such that, owing to the grates being set in the frame eccentrically, the ashes are removed from the bottom of the fire without permitting unburned fuel to drop into the ashpit.

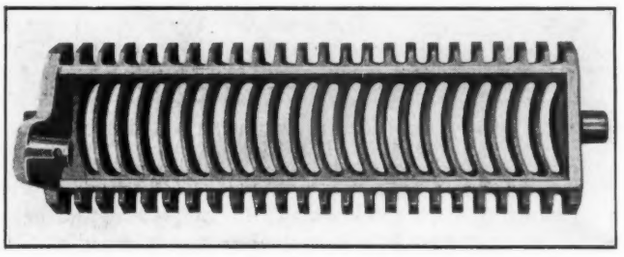


FIG. 3. UNDER SIDE OF THE CURVED CLIPS

This grate is manufactured by R. F. Morse Co., 86 Weybosset St., Providence, R. I.

The Chief Characteristics of Manganese Steel were summarized in a paper read before the International Engineering Congress, as follows: This steel usually contains 10 to 13 per cent. of manganese and approximately 1 per cent. of carbon. It is practically nonmagnetic and has a peculiar hardness, to which it owes a remarkable resistance to abrasion. It is extremely difficult to machine. It has high strength and toughness, but relatively low elastic limit. With care it can be forged and rolled. It has found its principal application in castings for crushing and grinding machinery and railroad crossings. Manganese steel has the peculiar property of being toughened and softened by quenching in water, resembling copper in this respect. All manganese steel castings are subjected to this treatment to remove brittleness.

Draft Gages on Oil-Burning Boilers

By F. H. Rosencrants

SYNOPSIS—The right and the wrong way of connecting draft gages to oil-burning boilers and the good and bad results which follow are clearly told.

A draft gage is the simplest, cheapest and most essential instrument used for indicating combustion conditions when properly applied to boilers using oil fuel. That this is not generally recognized by small-plant owners and operators has been made apparent to the writer from observation of many plants in Oregon. Most of the central-station plants are using them, but it is safe to say that not to exceed one in ten of the small isolated plants owns even one draft gage for from one to five or six boilers. The majority of those used are installed so that the information obtained from them is of doubtful value, and in many instances the valuelessness of the indications obtained have resulted in the disuse and disrepute of the instrument.

There is no investment in the boiler plant that will yield so large a return as that incurred in the purchase and proper installation of draft gages, one to a boiler—assuming, of course, that advantage be taken of their indications thereafter.

It is stated here that many gages as now used on oil-burning boilers are not properly installed, and such is the fact. This applies to central stations, as well as to isolated plants.

In most cases the gages are installed as shown in Fig. 1 and indicate the drop in pressure between the boiler room and the exit from the last pass. This is the most common connection found on coal-burning boilers and probably accounts for its use on boilers using oil. This connection is tolerated on coal-burning installations because usually the front dampers are kept wide open, in cases where there

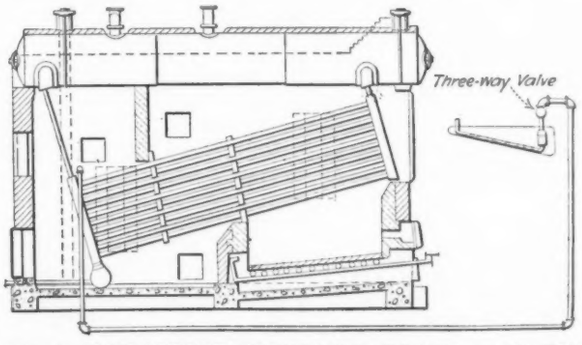


FIG. 1. IMPROPERLY CONNECTED DRAFT GAGE FOR OIL-BURNING BOILERS

are front dampers, and the fuel bed forms the major portion of the resistance to the gas passage. The most progressive coal-burning plants, however, have abandoned that connection and are using two draft gages, or their equivalent in a combination gage. One of these indicates the resistance of the boiler passes, being connected between the combustion chamber and the exit of the last pass; and the other indicates the resistance of the fuel bed, being connected between the combustion chamber and the boiler room.

In the few cases in which the draft is entirely controlled with the back damper, the front damper always remaining at the same opening, the gage connection, Fig. 1, for oil-burning boilers is not subject to serious criticism, since the obstruction to the flow of gases up to the gage connection remains constant and, therefore, the draft reading will vary with the rate of gas flow through the boiler.

The fallacy of the connection mentioned will be made apparent for any other method of control by a considera-

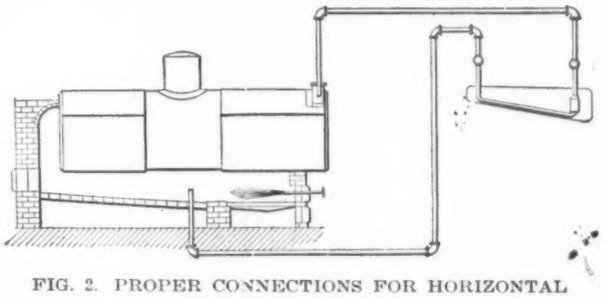


FIG. 2. PROPER CONNECTIONS FOR HORIZONTAL TUBULAR BOILERS

tion of the following: Suppose that the boiler is running under light load and the correct amount of air is admitted by having the back damper nearly closed and the front one wide open. Under such conditions the draft reading will be small. Now, suppose that, without changing the burner adjustment, the correct amount of air is admitted by opening the back damper and partly closing the front one. Assuming the same amount of air entering the furnace as before, the same total resistance to gas flow between boiler room and the top of the stack necessarily exists, but a large part of that resistance has been shifted from one side of the gage connection to the other; that is, from the back damper to the front one, so the draft reading will be materially greater than that obtained with the former damper arrangement. It is apparent from this that there is an unlimited number of damper combinations that will admit the same amount of air to the furnace and that every combination will give a draft reading that will differ from that given by every other combination. Hence, the draft readings obtained when both front and back dampers are used for regulating the air supply are worthless.

It might be suggested that the back damper be left at a fixed opening and all the regulating be done with the front one. While this is preferable to regulating with both dampers, it is far from ideal, for the following reason: An increased opening of the damper decreases the resistance to the gas flow between the boiler room and draft-gage connections, and at the same time increases the amount of gas flowing. The effect of the former is to decrease and of the latter to increase the draft reading. The net result is a slight decrease in draft, the amount of which between very light loads and heavy loads on the boiler is too small to be useful.

It is recommended by the writer that either all regulating be done with the back damper and the front one always opened the same amount, or that the gage be connected as in Figs. 2 and 3. In either case the resistance

offered to the flow of gases between the two points of connection of the gage is constant and the draft will vary with the rate of gas flow. The connections in Figs. 2 and 3 have the decided advantage, however, that the reading of the gages are affected by nothing except the rate of gas flow and are independent of the method of air-supply control.

The writer might add that, in any event, it is advisable, in so far as it is convenient to do so, to regulate with the back damper, keeping the front one wide open. By this

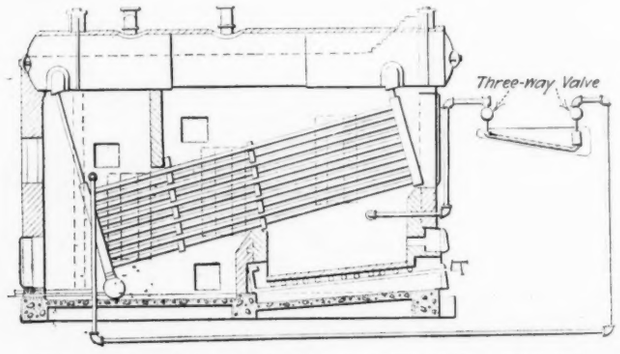


FIG. 3. CONNECTIONS FOR WATER-TUBE BOILER

means the pressure in the boiler setting is kept up to near that of the boiler room, and as a consequence the air of infiltration through the setting will be at a minimum. In fact, with a setting reasonably tight the air of infiltration is almost negligible, as the pressure inside the setting will, with most boilers, be seldom less than that of the boiler room by more than 0.10 in.

The fact that draft resistance of oil-burning boilers and their furnaces is small makes the air infiltration small, but the consequent small draft makes its indication, with sufficient accuracy to be of value, difficult with existing gages. It is important that the gage be checked frequently to be sure that it reads zero for zero draft. For the purpose of checking the zero reading, it is advisable to install three-way valves as indicated in Figs. 1 and 2.

To increase draft readings it may sometimes help to change the combustion-chamber connection down to the ashpit and thereby add the resistance of the furnace to the draft reading. This will usually be a mistake because the aspirator action of the burner makes the furnace resistance negative and reduces the draft below that which will be shown when the gage is connected as indicated in Figs. 2 and 3. The draft readings may be slightly increased by projecting the connection at the rear pass into the setting and putting an ell on the end of the pipe, turning its open end in the direction of gas travel.

With the draft gage properly installed, an experienced fireman can in a short time, by studying his furnace conditions in conjunction with the draft indication, determine the limiting values of drafts for the lightest and the maximum loads, and the approximately correct draft for intermediate loads. If the top of the stack is visible from a convenient point these values are easy to determine, as the fireman can then cut down on the air supply until a haze of smoke appears at the top, indicating the minimum amount of air. By careful study and observation of this sort he will soon become familiar with the amount of draft that should be indicated at all loads.

An Orsat gas-analysis outfit will be found valuable for studying the combustion conditions, as by its use the draft conditions for perfect combustion may be much more quickly and definitely determined.

"Glendora" Artesian-Well Pump

The "Glendora" triple-plunger deep-well pump is designed to operate three piston plungers within the one casing. Fig. 1 shows the triple-plunger design of the power head. The center crank is connected to the inside plunger rod, which carries the lower plunger, shown at the left in Fig. 2. On either side of the center crank and set at an angle of 120 deg. to it, are two cranks carrying a tubular rod which is attached to the middle plunger. The two outside cranks, set at an angle of 120 deg. to the others, are connected to the lower crosshead, to which is secured the tubular rod carrying the upper plunger shown at the right in Fig. 2.

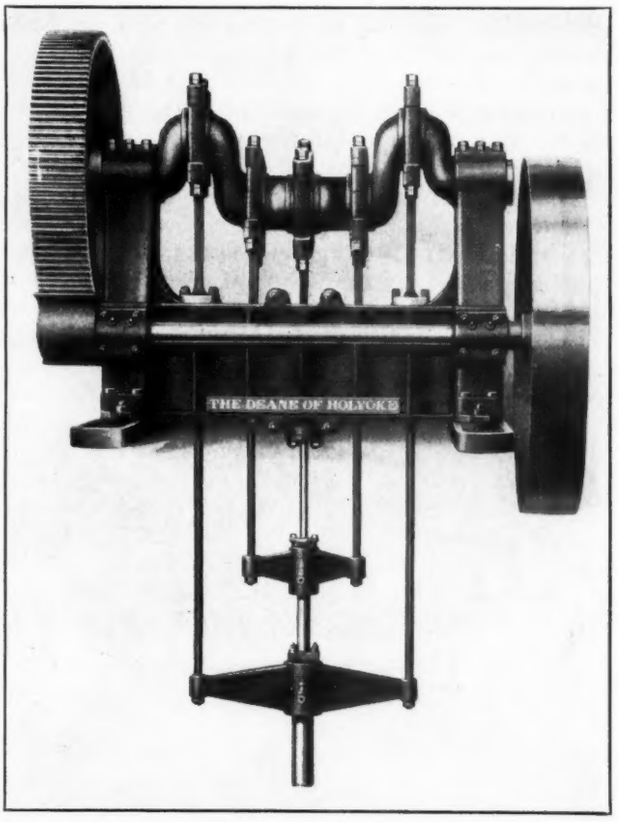


FIG. 1. GLENDORA TRIPLE-PLUNGER POWER HEAD

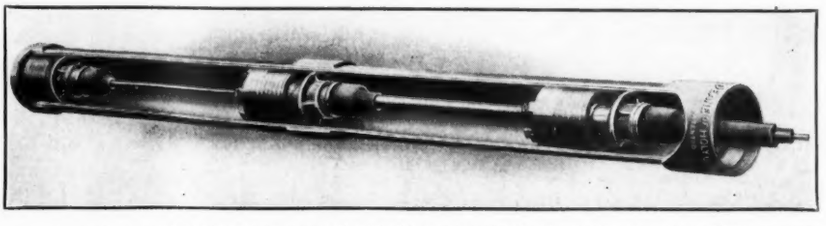


FIG. 2. SHOWING ARRANGEMENT OF THE WATER PLUNGERS

The crank angularity of 120 deg. gives a practically constant turning moment, and as the load comes on the

upstroke of each plunger it is evenly divided. The thrust of the connecting-rod is taken up by a crosshead guide placed at the bottom of the frame. The crankshaft is driven by a gearing, the pinion shaft being driven by a belt wheel. The crosshead is of the engine type construction, the body of which forms an oil pocket. The shoes are fitted with a standard taper for adjusting.

This pump is manufactured in various sizes at the Deane Steam Pump Co. plant of the International Steam Pump Co., Holyoke, Mass.

Mail Conveyor for Government Printed Matter

By W. R. Metz

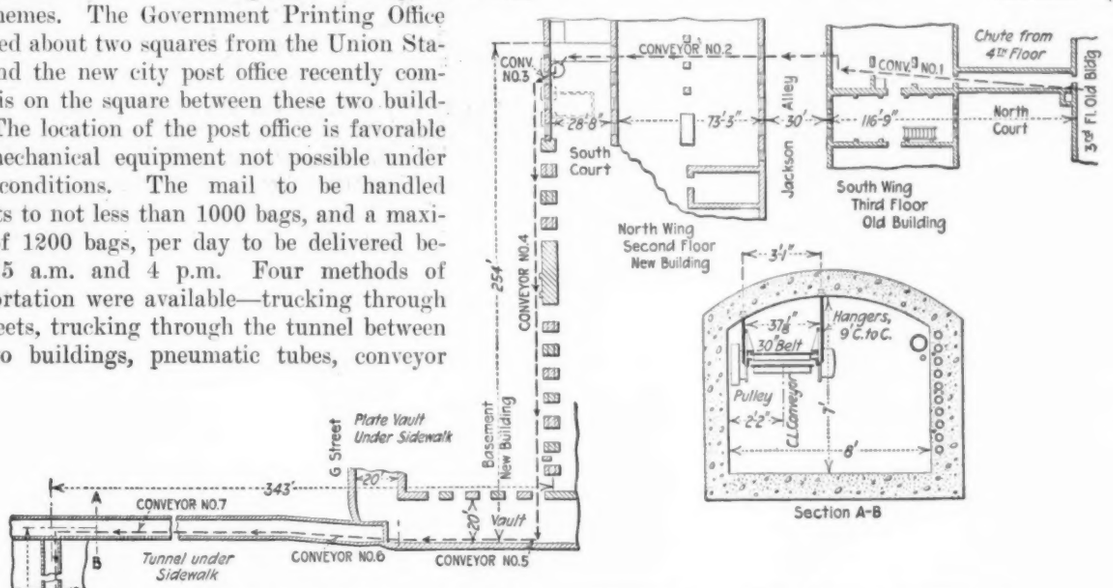
SYNOPSIS—This article describes a comprehensive study of means of transferring material from one point to another, and is not confined in its application to the one use. The small amount of power consumed is one of the features.

Government printed matter, consisting of reports of the various branches of departments, has been increasing by leaps and bounds during the past few years, and has finally reached such proportions as to make mechanical means of handling it advisable, and the writer was instructed to make an investigation and report on feasible schemes. The Government Printing Office is located about two squares from the Union Station, and the new city post office recently completed is on the square between these two buildings. The location of the post office is favorable to a mechanical equipment not possible under other conditions. The mail to be handled amounts to not less than 1000 bags, and a maximum of 1200 bags, per day to be delivered between 5 a.m. and 4 p.m. Four methods of transportation were available—trucking through the streets, trucking through the tunnel between the two buildings, pneumatic tubes, conveyor belts and chutes. The mail matter is placed in ordinary mail bags varying in size from 16x16x36 in. to 8x24x36 in., and varying in weight from 50 to 150 lb. per bag. The equipment for trucking consisted of electric-driven vehicles of 5000-lb. capacity. As the truck had to be loaded at the printing office and unloaded at the post office, each round trip required nearly an hour, so that two trucks would be required, with an estimated annual operating cost as follows:

Cost of equipment		$6009.00
Labor (three operators on each truck, at $751.20 each)	$4507.20	
Maintenance and repairs to trucks, based on actual cost	1500.00	
Depreciation at 10 per cent	600.00	
Interest on investment at 5 per cent	300.00	
Total operating cost		$6907.20

The second method—trucking through the tunnel—would require mechanical means for delivering the bags to the tunnel and to the mailing floor in the post office. An estimate for an installation of this kind follows:

Three electric-driven baggage trucks, 42 in. wide by 72 in. long, having a capacity of 2000 lb. each		$4,000.00
Belt conveyors and spiral chutes from the various floors to the sending station		12,000.00
Total		$16,000.00
Maintenance and repairs for three trucks (based on actual operating cost of 2000-lb. electric trucks), at $421.50 each	$1,264.56	
Five operators at $751.20 each	3,756.00	
Operator for belt conveyors	751.20	
Power for operating belts	156.50	
Maintenance	400.00	
Depreciation at 10 per cent	1,600.00	
Interest on investment at 5 per cent	800.00	
		$8,728.26



ROUTE AND DISTANCE BAGS ARE CONVEYED WITHOUT MANUAL HANDLING

The pneumatic-tube systems would require a terminal station at each building, and would also require mechanical equipment for delivering mail to the sending station and from the receiving station to the mailing floor in the post office. Equipment and estimated operating cost follows:

Cost of pneumatic tube system, including conveyor from upper floors to sending station		$30,000.00
Operating cost:		
Two operators at $751.20 each	$1,502.40	
Power (estimated) per year	150.00	
Maintenance (estimated) per year	150.00	
Depreciation at 10 per cent., interest on investment at 5 per cent.	4,500.00	
Total		$6,302.40
Cost of operating belt and spiral chute power (estimated) per year	$20.00	
Maintenance per year	400.00	
Total		420.00
Total cost of operating tube system and conveyors		$6,722.40

The endless belts and chutes appeared from the outset to be the most feasible because they would require no rehandling at intermediate points. The estimated cost of this equipment follows:

Equipment		$25,000.00
One operator at $751.20	$751.20	
Cost of current per year (313 days)	37.50	
Maintenance	500.00	
Depreciation (10 per cent.)	2,500.00	
Interest (5 per cent.)	1,250.00	
Total annual cost of operation		$5,038.70

As a result of these studies specifications were drawn for a belt conveyor, but with a clause inserted allowing bids based upon other types as alternates.

The specifications called for a series of eight conveyor belts in all and a spiral chute, this chute being so designed that mail bags could be delivered to it from the second, third, fourth and fifth floors of the printing office, as well as from the belt conveyors, which were to run as follows:

No. 1, near the ceiling of the third story, receives bags from the fourth floor, discharging by means of a chute to conveyor No. 2.

No. 2, near the ceiling of the second story, extends across an alley, through the "north wing" of the building, then across the "south court" and discharges into the spiral chute leading to the basement.

No. 3 runs from the base of the spiral chute in the basement and discharges onto No. 4.

No. 4 runs through the basement, near the ceiling line, extending to the east wall of the building, and discharges onto conveyor No. 5.

No. 5 runs through the "plate vault" to the entrance of the tunnel between the two buildings, discharging onto conveyor No. 6.

Nos. 6, 7 and 8 are in the tunnel and finally discharge into a bucket lift, which delivers the bags to the mailing room of the post office.

The total length of all conveyors is 983 ft., or a total belt length of 1997 lin. ft.

The conveyor belts are of 4-ply high-grade canvas and rubber, 30 in. wide, to stand a friction test of 12 lb. per inch of width, to run at from 120 to 180 ft. per minute and be capable of handling 150 sacks of mail per hour of the sizes and weights before mentioned.

All belts are driven by slow-speed, shunt motors with variable field control, wound for 220 volts, direct-current and fully inclosed. The wiring to the motors is so arranged that it will be impossible to operate any conveyor unless the one ahead of it is running, thereby rendering it impossible to have an accumulation of mail at any one point.

A system of signal lights is also provided to show a light at each entrance to the spiral chute and at conveyor No. 1 when the machinery is in operation, and also to indicate on a central switchboard whenever any motor in the system is not in operation. An electric signal bell is provided at each motor, each such signal being supplied with a return call to an annunciator located at the central switchboard.

In order to determine the bid best suited and the cheapest in the end, an evaluation basis was adopted providing that bidders must submit in their proposals the power required to operate the system bid on, for each twelve hours, when in full operation. The sum of the savings when operating under the given conditions represents the gross savings per year effected by the system, with lower labor and power cost, over the system with higher costs.

If the gross yearly savings, as computed, exceed 16 per cent. depreciation and 3 per cent. interest charges of the difference between the amount of the bids, the bid for the system with lower operating cost was to take preference over the bid for the system with higher operating cost.

The award for the work was made to the Lamson Co., of Boston, Mass., at $25,098, its proposal guaranteeing that the entire system when operated at a conveyor speed of 120 ft. per minute will not exceed 9.7 kw., or 116.4 kw.-hr. for a 12-hr. run.

On a preliminary run there were 115 bags of mail delivered in 14 minutes (or about 8 bags per minute) to the post office without a hitch. If this rate were kept up, there would be delivered nearly 500 bags of mail per hour, thus demonstrating the value of this type of conveyor and that the original assumptions were correct and more than justified the selection of this system.

The following table shows the length of each belt and the size of motor used on each:

Conveyor No.	Length C. to C. of Pulleys, Ft.	Horsepower of Motor
1	125	1.00
2	130	1.05
3	15	0.375
4	216	2.50
5	84	1.05
6	52	1.00
7	216	2.50
8	145	1.05
	983	10.525

The total length of the conveyors (center to center of pulleys) is 983 ft.

The 12-hour efficiency test of the system showed a total current consumption of 43.1 kw.-hr., or an average of only about 3.6 kw. per hour, which is extremely low considering the work done. It is interesting to note that there is practically as much power consumed in operating the various belts without load as when fully loaded.

During this test bags of mail were fed into the conveyor from two different points, the highest rate of delivery being 80 bags in 15 minutes, giving a rate of 320 bags per hour, which the conveyors handled without difficulty, although the guaranteed capacity was only 150 bags per hour.

This equipment will be a time as well as a money saver, for it will now be possible to catch trains for the West which leave very soon after the mail is sacked, whereas under the old system the next train had to be used, often necessitating as much as twelve hours delay.

Lower Rates in Idaho—The Public Utilities Commission of Idaho has made deep cuts in the power and light rates of the Northwest Light and Water Co. in Idaho. Residence lighting will average a reduction of one-third and business houses will get the same or more, according to the consumption. The rate ranges from 10c. for the first 20 kw.-hr. per month to 2c. for 500 kw.-hr.; all in excess of 500 kw.-hr. per month, 1c. In some cases the reduction will amount to as much as 71 per cent., and the company has argued that some of the rates will compel it to furnish power at less than actual cost, resulting in a loss. The commission conceded that 10 per cent. was a fair return on the company's investment, but upon the valuation of its property there was a wide discrepancy in the figures of the commission and those of the company.

Correction: Charts for Estimating Strength of Bolts—In Chart No. 1, on page 42 of the Jan. 11 issue, the areas at the root of the thread, for bolts ¼ to ⅞ in., inclusive, are misstated. The decimal point should be before the cipher, making the respective sizes 0.627, 0.045, 0.068 and 0.093, instead of those given in the chart.

Regulating the Capacities of Air Compressors

With the adoption of the "Simplate" valve described in the Nov. 2 issue of *Power*, the Chicago Pneumatic Tool Co. has made a number of improvements in its various types of air compressors. Perhaps the most notable improvement is the capacity regulation on all power-driven compressors. On medium-sized machines the regulation is two-step, but on compressors having a stroke 14 in. and above, four-step regulation is used when the service conditions make it desirable. This regulation consists of holding open by air pressure certain air-inlet valves and returning to the atmosphere a portion of the air drawn into the cylinders. In this way a delivery equal to the demand is obtained, insuring high economy at all underload points.

For the two-step control unloading inlet valves are provided in connection with differential unloaders. One

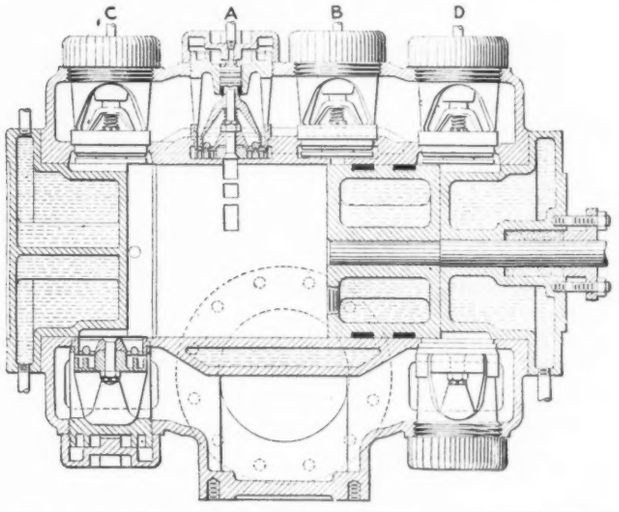


FIG. 1. INLET VALVE ARRANGEMENT FOR FOUR-STEP CAPACITY REGULATION

of the latter is piped to the inlet valve at the head end of the high-pressure cylinder and at the crank end of the low-pressure cylinder. The other unloader is piped to the inlet valve at the crank end of the high-pressure cylinder and the head end of the low-pressure cylinder. The first unloader is adjusted to operate at a pressure of 100 lb., and the second at 104 lb. Operation of the first unloader holds open the inlet valves at opposite ends of the high- and low-pressure cylinders, so that air is compressed in only one end of each cylinder, and the compressor operates at one-half load. When the other unloader operates, the rest of the inlet valves are held open and the compressor runs under no load.

The four-step regulation is similar except that four unloaders are employed instead of two, and to provide the four steps two intermediate sets of valves in the air cylinder are located midway in the stroke of the piston. As described for the two-step regulation, the unloaders are piped to alternate ends of the cylinders, so that when the crank end of the low-pressure cylinder is unloaded the inlet valves at the head end of the high-pressure cylinder are also held open, giving, as nearly as can be obtained, a balanced condition for each complete revolution and at the same time maintaining the correct cylinder ratio. The unloaders are set to operate at about 2 lb. difference in pressure between the successive steps. For example, the first unloading step will occur at 98 lb. pressure, the second at 100 lb., the third at 102 lb. and the fourth step at 104 lb., when the compressor will

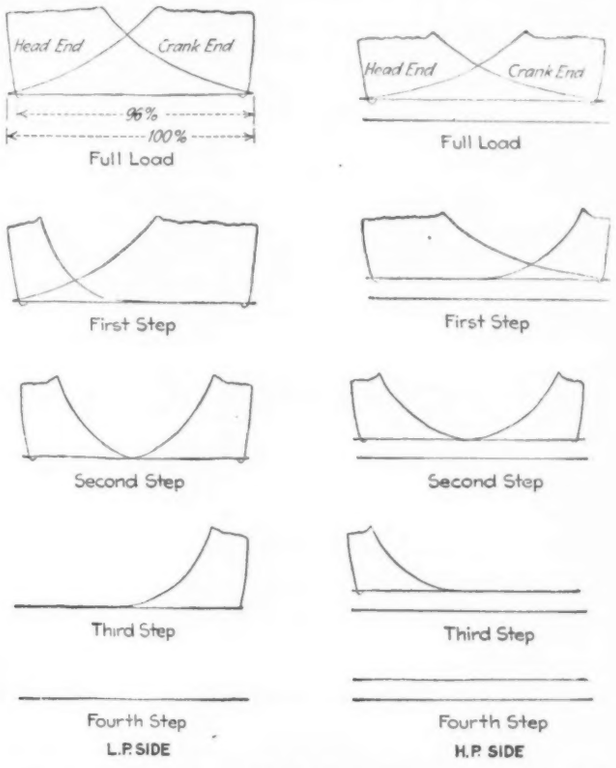


FIG. 2. INDICATOR DIAGRAMS, SHOWING THE EFFECT OF REGULATION

be completely unloaded. In the individual unloader the range between the point of loading and unloading is about 8 lb., so that the pressure is dropped to 96 lb. before the first step will go into action again, and the next three steps will operate at 2-lb. intervals.

Fig. 1 is a sectional view of an air cylinder showing the arrangement of the inlet valves for four-step capacity regulation. This view indicates the employment of four distinct sets of inlet valves, distributed along the length of the cylinder, each set being under the control of a differential regulator that may be adjusted to operate at any desired pressure. For three-quarter load, inlet valves *A* are held wide open and the air is returned to the atmosphere until the piston passes the ports to these

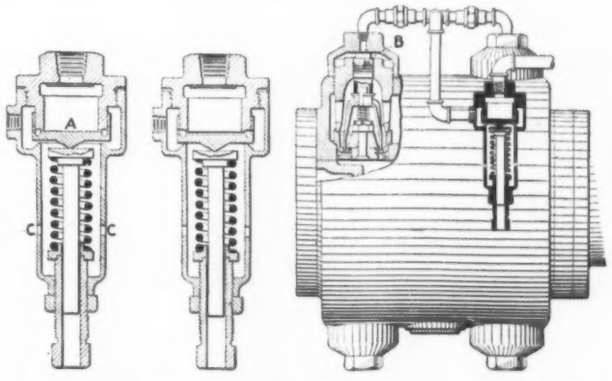


FIG. 3. DIFFERENTIAL REGULATOR AND APPLICATION TO UNLOADING MECHANISM AT COMPRESSOR VALVE

valves. For one-half load valves *A* and *B* are held open, and for one-quarter load valves *A*, *B* and *C* are held open. For no-load all inlet valves are open. The indicator diagrams reproduced in Fig. 2 show the effects of the different steps of the regulation.

Fig. 3 shows a sectional view of the differential regulator and the application of the regulator and unloading mechanism. The unloader is provided with a valve that has areas that are different for the loaded and unloaded positions. As shown at *A* in Fig. 3, the valve is cup-shaped and is guided by a cap screwed into the top of the body of the regulator. On the bottom of this cap is a narrow seat against which the valve is held by the pressure of a spring. In its loaded position, or in other words, when the valve is pressed up against its seat on the bottom of the cap, the area against which pressure is applied is less than when the valve is in the unloaded position, or down against the seat on the opposite side. When the air pressure in the receiver increases to the point for which the regulator is set, the pressure forces the valve down against the pressure of the spring. Consequently the pressure builds up on top of piston *B*, forcing it downward, and in turn the forked member which holds the valve open. When the pressure in the receiver reduces to the prescribed limit, the spring forces the valve back against its upper seat, and the pressure on top of the piston of the unloading mechanism is released through holes *C* in the casing of the regulator. A spring raises the forked member off the valve and allows it to resume its normal functions.

Operating Characteristics of the Venturi Meter

By Charles G. Richardson

SYNOPSIS—Considers why feed pump pressure need not be increased to force water through meter; why meter registers accurately in any position; overload possibilities; use of air chambers; and how to correct for variations from standard temperatures.

During conversations with engineers of many power plants throughout the United States, I have found that a lack of certain specific information regarding the venturi meter has resulted in erroneous conclusions. This information, which is not available either in the usual sources of engineering data or in catalogs, is given in the present article.

The interior contour of a venturi-meter tube is shown to scale in Fig. 1. If water were flowing through the meter tube, the water in the tube at *A*, *B* and *C* would rise to the comparative heights indicated. The water at *B* would be considerably lower than at *A* and *C*, showing a decided drop in pressure at *B*. This is caused by the great increase in velocity through the throat *B*. A portion of the head or pressure at *A* has been changed into kinetic energy, or the energy of motion. If there were no outlet cone *BC*, the pressure at the feed pump would have to be increased, since the loss at *B* may amount to as much as 10 lb. if the meter is operating at maximum capacity. The cone *BC*, however, reverses the action; the water begins to decrease in speed after passing *B*, and when *C* is reached nearly all of the pressure at *A* has been restored. The friction loss between *A* and *B* varies from ¼ to 1 lb., as the meter is operating from one-half to full capacity. These facts explain why there is practically no increase required in steam pressure at the feed pump in order to force water through the throat of the meter tube.

The basic principle of the venturi meter is that for every rate of flow in "lb. per hr." (or other units), there is a definite difference in pressures at the inlet and at the throat of the tube. The principle holds good even if the meter is installed in other than horizontal positions. Consider Fig. 2, which shows the meter tube in the vertical discharge line of a centrifugal pump. The water has a velocity at the inlet of v_1 and at the throat of v_2. Suppose that glass tubes *D* and *E* are inserted to show the head of water. The floor *MN* is used as a reference plane, although any other horizontal line might be selected. *H* is the difference in head (the venturi head) between inlet and throat. It may be assumed that the same weight *W* of water passes through the inlet and throat at the same second. Therefore, neglecting friction, there should be no loss of energy between these two points.

Let We_1, Wh_1, and $\frac{Wv_1^2}{2g}$ represent the potential, pressure and kinetic energy, respectively, at the inlet, while the corresponding energies at the throat are designated by We_2, Wh_2 and $\frac{Wv_2^2}{2g}$. The sum of the energies at the inlet and throat should be equal. Equating the sums,

$$W\left(e_1 + h_1 + \frac{v_1^2}{2g}\right) = W\left(e_2 + h_2 + \frac{v_2^2}{2g}\right)$$

But as $e_1 + h_1 = H_1$ and $e_2 + h_2 = H_2$,

$$H_1 + \frac{v_1^2}{2g} = H_2 + \frac{v_2^2}{2g}, \text{ or } H_1 - H_2 = \frac{v_2^2}{2g} - \frac{v_1^2}{2g} = H.$$

This is the usual formula for the venturi meter, and and since the velocity does not depend upon the position of the tube, the equation is true for any position of the meter. No matter how it is placed, the meter does not have to be either specially graduated or corrected for the difference in elevation between inlet and throat.

If the feed water is "bad," that is, if it contains scale-forming constituents, there is the same tendency to form scale in the inlet and outlet portions of the meter tube as there is in the main feed line. The throat, however, by reason of the comparatively high velocity of the water therein, tends to clean itself automatically. Furthermore, the throat portion contains a bronze lining. This metal resists corrosion from feed water more than does cast iron or steel. Meter tubes have been removed that have shown a coating at the throat, although, curiously enough, this portion of the deposit is nearly always smooth, as if laid

on with a trowel. Scale and tubercles forming in the outlet cone of the tube have no effect on the accuracy of the meter. These formations do increase somewhat the friction loss between the inlet and outlet. Scale forming in the inlet does not seriously affect the accuracy unless so located as to cause excessive eddy currents at the inlet pressure chamber vents. For instance, in a 4-in. meter tube with a 2-in. throat, which is an average size, scale $\frac{1}{8}$ in. thick on the side, reducing the inlet area to $3\frac{3}{4}$ in., would mean only a 1 per cent. error. Scale forming in the throat, however, will produce an error in registration almost proportional to the reduction in area.

The high velocity at the throat tends to keep it clear, but if the major dimension of any foreign object in the water is greater than the throat diameter, the object may become lodged in the throat. The effect on the meter is to materially increase the velocity at the throat, and hence to give a pronounced and false increase in the reading of the recording instrument. The differential pressure caused by the increased velocity may become so great as to blow the mercury out of the instrument into the pressure piping. The ball check valve usually provided in the instrument prevents this occurrence.

In the issue of July 20, A. E. Baker states that a pump valve lodged in the throat of a venturi meter was discovered by the indications of the instrument. To avoid a repetition of this, a copper disk, drilled with $\frac{5}{8}$-in. holes and forming a strainer, was placed in the feed line between the pump and the meter tube. Whether this is good practice, however, is questionable, as the strainer itself may become clogged.

A bypass should be provided around the meter tube when there is no auxiliary line for feeding the boiler. The tube may then be removed for examination or to change the size. The proper method of installing the meter tube and bypass, Fig. 3, involves the use of three valves. The bypass line should be above the meter tube to avoid collection of sediment. It can be of smaller size than the main line, since its total length is relatively short. It is not good practice to put the meter tube in a bypass line. A straight length of pipe should immediately precede the inlet of the meter tube.

Theoretically, the limiting distance between the meter tube and the recording instrument is that at which there is no longer sufficient pressure to raise the water. Practically, however, 300 ft. is rarely exceeded, since operators may not thoroughly blow out the two pressure lines between the tube and instrument at regular intervals, and thus rid the apparatus of entrained air that may seriously affect the instrument's accuracy.

The rated capacity of a venturi meter may be almost doubled without greatly increasing the pressure at the pump. The friction loss through the meter would then amount to four or five pounds. The recording instrument, however, would indicate only its maximum rate, and the registration would be incorrect during the period of excess load. The capacity may be increased by substituting a throat of larger diameter, replacing one or two sections in the tube (a new tube of larger size is required if the largest throat is already in service) and adding to the recording device dials and charts graduated for the new throat.

When centrifugal or triplex pumps are used, an air chamber in the feed line is unnecessary owing to the comparatively steady rate of discharge. Duplex pumps often give an extremely irregular flow, but if the meter tube is between a heater or economizer and the boiler, the former tends to "smooth out" the fluctuations and may render an air chamber unnecessary. Single pumps, whether double- or single-acting, invariably require an air chamber. The pump fluctuations that are sufficiently severe to require an air chamber for securing meter accuracy also produce on the pump valves and fittings a destructive water-hammer which the air chamber will nullify. The July 8, 1913, issue of *Power* contained an

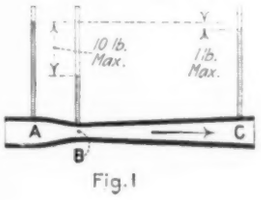


Fig. 1

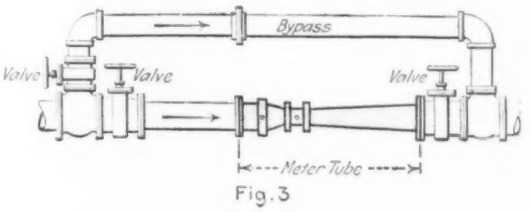


Fig. 3

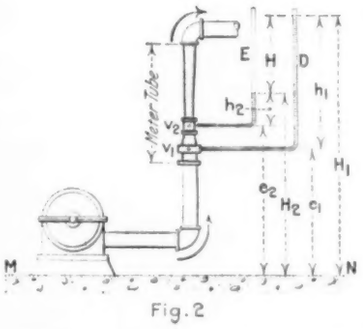


Fig. 2

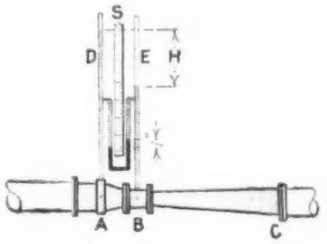


Fig. 4

Fig. 1—Meter-tube contour. Fig. 2—Tube in pump discharge. Fig. 3—Bypass Layout. Fig. 4—U-tube on meter

article on the design, proportions and location of air chambers.

While the venturi meter is graduated for a standard temperature of 62 deg. F., the factor of correction for other temperatures is different from that of the ordinary displacement meter. This may be explained with the help of Fig. 4. Suppose that glass tubes D and E were inserted at inlet A and throat B and that they transmit pressures through the corresponding length of a U-tube containing mercury. The head H is then produced and always represents the difference in head of the liquid flowing through the tube, no matter whether it is cold water, hot water, brine or some other liquid. If the liquid is water at 62 deg. F., then the scale readings are correct, and for 1 in. difference in mercury column $H = 12.6$ in., not 13.6 in. The latter value is often and incorrectly taken in translating feet of water differential to inches of mercury in the venturi formula. Now imagine that water of a different temperature is sent through the meter tube, but that the mercury column still shows 1 in. difference in pressure. H then must have changed to $\frac{H}{s}$, where s represents the specific gravity of the hot water. Let Q equal the volume of the water discharged

at 62 deg. F., and Q' that discharged at any other temperature; W the total weight of water in pounds per cubic foot at 62 deg. and W' the total weight of water discharged at any other temperature and w the weight per cu.ft. discharged at 62 deg. F. Then for the same period of time

$$\frac{Q}{Q'} = \left(\frac{\frac{H}{s}}{H}\right)^{\frac{1}{2}} = \frac{1}{s^{\frac{1}{2}}}$$

Also

$$\frac{Q'ws}{Qw} = \frac{W'}{W} \text{ or } \frac{Q'}{Q} = s^{\frac{1}{2}}$$

Hence to correct for temperatures other than 62 deg. F., when the readings of scale S, Fig. 4, are in gallons or cubic feet, divide by the square root of the specific gravity of the liquid. When they are in pounds, multiply by the square root. In other words, for water hotter than 62 deg. F., the true volume is greater or the true weight is less than the volume or weight shown by the scale. Owing to the square root, the correction factor is only about one-half that of the positive-displacement meter factor, although the latter as its name implies, registers volume correctly no matter what the temperature is. This method takes no account of increase in throat area caused by circumferential expansion. Calculation, however, will show this to be a negligible amount, and furthermore it would be impossible practically to determine the effective change in throat temperature.

Taking Oil from Feed Water

By R. A. Langworthy

SYNOPSIS—Oil in the feedwater so coats the tubes that the time lost and the expense incurred induced the writer to lay out a system of drains and separators for catching the oil. The system is described and illustrated and should be of value to the many engineers who experience like trouble.

Some years ago I took charge of an electric-light station of about 2500 hp., and one of the first troubles that came to my attention was oil in the boilers. These were of the water-tube type and the continual renewal of tubes had become a serious matter from the standpoint of expense and operation, as the boilers could not be taken off of the line except on Sundays.

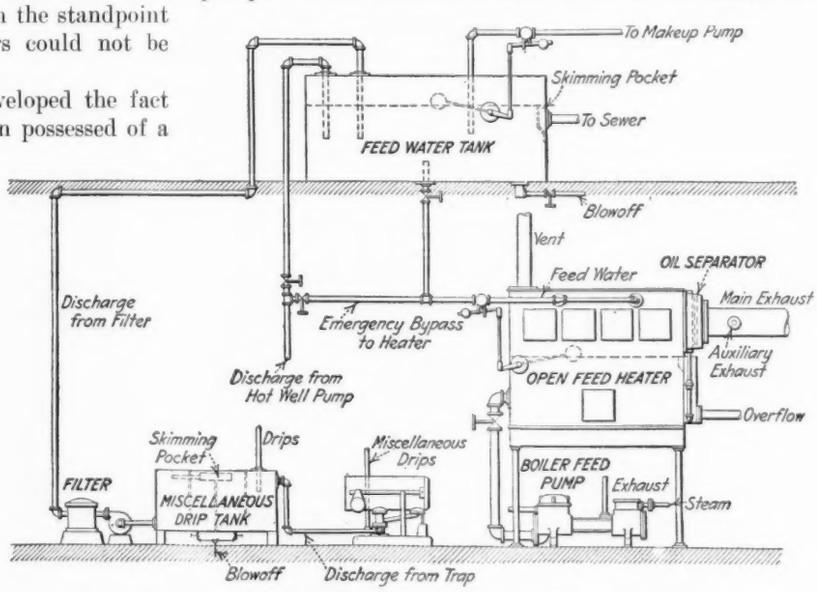
A careful analysis of the situation developed the fact that one of the former engineers had been possessed of a mania for saving all hot water, drips, etc., regardless of their source of purity, and had arranged to return them to the boilers. The boiler feed in addition to the makeup water, was taken from the following sources:

1. Condensation from a 500-kw. turbine.
2. Exhaust from three reciprocating engines that were used on an exhaust-steam heating system in the winter and run noncondensing in the summer.
3. Exhaust from various plant auxiliaries such as boiler-feed pumps, step-bearing pumps, turbo-exciters, etc.
4. Drips from high-pressure steam lines.
5. Drips from exhaust lines.
6. Drips from exhaust-steam heating-system main-line separator at power house.
7. Miscellaneous drips, such as throttle valve, cylinder drains, etc.
8. Drips from oil separators.

The various drips were returned directly to the boilers without any attempt to remove the oil, so there was no mystery as to the source of the trouble. Each item was considered fully, both as to the amount of available hot water and the liability of oil being present. When oil is emulsified, it is rather difficult, if not impossible, to remove it entirely from the water. When the hot water or exhaust steam contains a relatively large percentage of oil, it is in the interest of real economy to forego any means of saving it.

A system was devised covering the entire plant and is shown in diagrammatic form. The different items were disposed of as follows:

1. This water was the condensation of the turbine taken from a surface condenser. It contained no oil and was pumped to the boiler-feed tank direct to the heater for emergency use. The water from this source was most of the total.



PIPING AND EQUIPMENT WHERE OIL IS WELL SEPARATED FROM FEED WATER

2. This quantity varied with the season, being a maximum in the summer when the exhaust-steam heating system was shut down. It contained some oil, as is usual in the ordinary engine exhaust. The oil was completely removed by the oil separator and filter chamber.

3. This steam was passed through an exhaust-steam oil separator in its own line and then turned into the main

engine exhaust line where it also passed through the main oil separator and filter in the open heater. By this means the oil was reduced in quantity so it gave no appreciable trouble. I have found that the auxiliary exhaust usually contains more oil than the main exhaust, especially where there are many reciprocating pumps. It is therefore good practice to place an oil separator on the auxiliary exhaust line to remove part of the oil before it reaches the main exhaust. Oil separators of liberal size should always be chosen and provided with traps.

4. These drips were provided with a Holly system, which returned them direct to the boiler. They contained no oil, so were not treated specially.

Handling the Exhaust Drips

5. These drips were a fertile source of oil, and being of considerable amount, it was finally decided to save them and remove all the oil possible. They were piped to one large trap and thence discharged into a "miscellaneous drip tank" provided with a skimming trough and a series of baffle plates, as indicated. The baffles served to separate the oil and water. Here is where the skimming trough got in its good work. I found it to be very effective when properly used. Water is run continuously into the drip tank in a small amount—just enough to keep the level a short distance above the edge of the skimmer. It was supplied in this case mainly by the cooling water from the dry-vacuum pumps and the turbine oil filter. The oil floating on the surface is drained off into the skimming trough and discharged to the sewer. The quantity of drips was fairly uniform throughout the day, and it is surprising how little attention was required to keep the water level in the tank near enough to normal. The water was drawn from the last compartment of the tank by a small motor-driven centrifugal pump and forced through a filter to the boiler-feed tank. The elements in this filter were renewed every twenty-four hours to maintain the efficiency of the filter.

6. The drips from the exhaust-steam heating system were only those from a separator in the main line where it left the plant and were treated in the manner described in item No. 5.

Some Oil Thrown Away

7. The drips under this head were small in quantity and contained a very large amount of oil. It was decided not to attempt to use them and they were piped to the sewer.

8. These drips were treated as item No. 7.

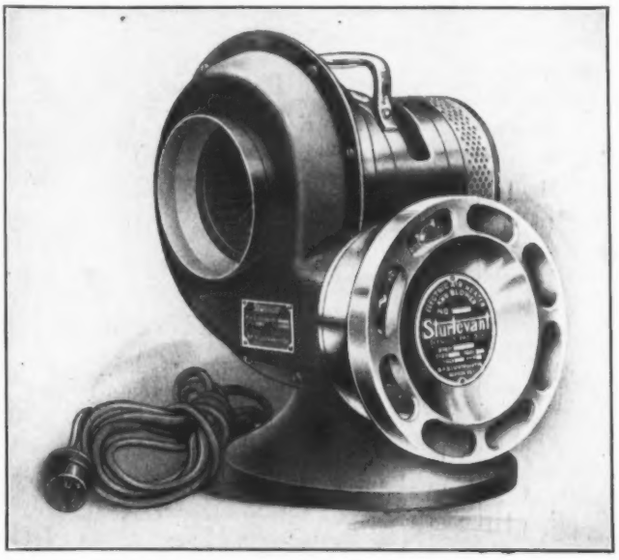
The various drips and the boiler make-up water were discharged into the boiler-feed tank, which was also provided with a skimming trough. The makeup water was controlled by a float valve, which kept the water level constant and enabled the skimmer to work effectively. The boiler-feed tank was of considerable size to allow for load fluctuations. Water was drawn from this tank to an open heater that contained a filtering chamber and thence to the boiler-feed pumps.

The scheme outlined was erected as shown and proved to be very effective. Within a short time after its installation the trouble with oil disappeared and the outfit required little attention. I do not believe that the device described, or any other, will remove all of the oil. Chemical analysis would probably indicate that oil was present, but in such small quantity as to be practically negligible.

The Sturtevant Electric Heater and Blower

An electric heat blower, illustrated herewith and recently put on the market, consists of a small motor-driven fan discharging air through heating coils placed in an aluminum casing.

The set, made by the B. F. Sturtevant Co., of Boston, Mass., is made in five sizes and delivers air at one, two



STURTEVANT ELECTRIC HEATER-BLOWER

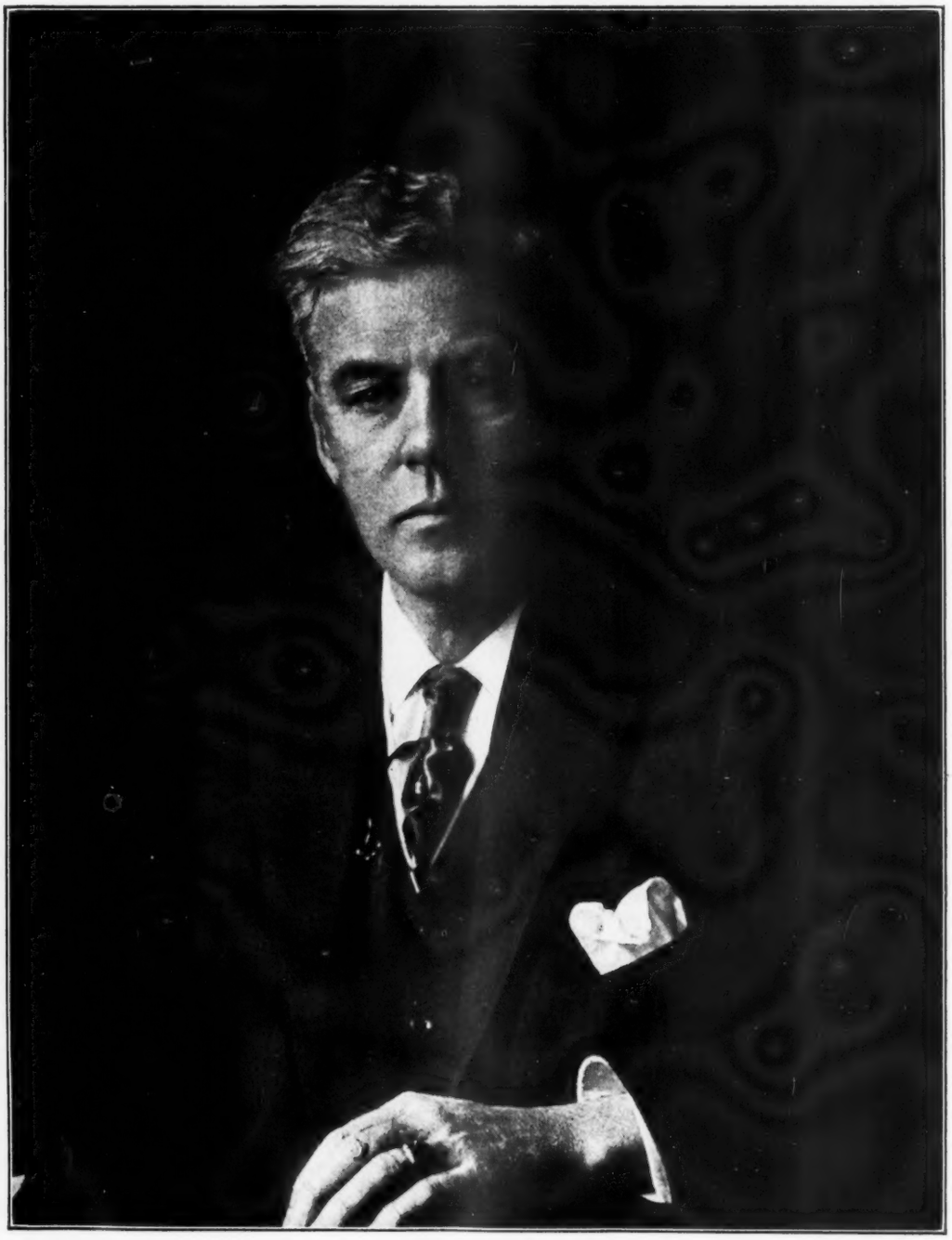
or three temperatures, depending on the size. The fan outlet can be turned so as to discharge in any direction. The temperature of the air delivered depends on the position to which the switch, mounted on the base, is turned.

Artificially Softened Water Reduces Rusting

Corrosion tests were made with plates of cast iron and mild steel in distilled water, tap water, and tap water softened by means of Permutit, according to the *Journal* of the Society of Chemical Industry, Sept. 30, 1915. Rusting (loss in weight) was found to correspond with the amount of dissolved oxygen in the water, and this was greatest at temperatures above atmospheric in the softened water.

Experiments with added sodium sulphite showed that the dissolved oxygen could be reduced quantitatively, but at ordinary temperatures the reaction was very slow. At higher temperatures and when traces of copper salts were present, it was considerably accelerated. Tests made with both softened and unsoftened waters to which sodium sulphite had been added showed that the addition of the salts prevented rusting both at ordinary temperatures and at 211 deg. C., say 290 lb. steam pressure.

Correction: "Actual Cost of a 2,900-Kw. Steam Plant"—Owing to an omission in the transcription of data in the article on page 18, issue of Jan. 4, the size of the plant was incorrectly stated. The station rating should have been 3,750-kw., the units being one 1,200-kw. and three 850-kw. machines. The corrected unit cost of the entire station is $100.57 per kw. The costs of the individual equipment items are correct as published, as are also the totals.



John A. Reed

John Alexander Hill

John Alexander Hill, organizer and president of the Hill Publishing Company, was stricken with heart failure while on his way to the office on Monday morning, January twenty-fourth, and expired before a physician could reach him.

The deceased was born at Sandgate, near Bennington, Vt., on February 22, 1858. His father, George A. Hill, was a wagon-maker with a leaning toward farming and emigrated to Mazomanie, Wis., when the son was five years old. The boy's early life and opportunities were those afforded by a farming community in a newly settled country. The twig was bent in the direction of his life's work when, at the age of fourteen, he went to work in a small printing office, and his ability and force even at that early age are indicated by the fact that at seventeen he was its foreman. At twenty his fondness for machinery led him to acquire a half-interest in a small machine shop and later to seek a position upon the Denver & Rio Grande Railroad, where he began as fireman and within a year was driving a locomotive up the steeps and around the edges of the cañons of the Rockies.

In this work his observing mind saw things and thought thoughts that he wanted and needed to share with others, and his experience in the printing office furnished the outlet. He was a frequent and valued contributor to the *American Machinist,* of which his quaint and practical stories of railroad and roundhouse life were a favorite feature.

In 1885 he left the railroad and founded the *Daily Press* at Pueblo, Colo., and edited it for a year, but returned to the railroad until he was called to New York in 1887 to edit the *Locomotive Engineer,* which the American Machinist Publishing Co. was starting.

In 1891 he and Angus Sinclair bought the *Locomotive Engineer* and changed its name to *Locomotive Engineering.* Some of Mr. Hill's best writing was done at this time. His "Jim Skeever" is a real personality to many locomotive engineer readers, and his breezy way of putting real human interest into practical mechanics won for the paper a live, interested clientele. His experience as an engineer and roundhouse foreman had taught him the weaknesses and evils of the old rule of promotion according to time of service. He advocated a system of promotion by merit which, as embodied in his "Progressive Examinations for Locomotive Engineers," was adopted by the Master Mechanics' Association as the standard for examinations on American railroads.

In 1896 Mr. Hill and Mr. Sinclair bought the *American Machinist* and a year later parted company, Mr. Sinclair carrying on *Locomotive Engineering,* while Mr. Hill gave his entire attention to the *American Machinist.* In 1902 he organized the Hill Publishing Co. and acquired *Power.* In 1905 the new company became the owner of the *Engineering and Mining Journal,* in 1911 established *Coal Age* and in 1911 bought *Engineering News.* The *American Machinist* is published in England and Germany.

As a publisher Mr. Hill was farsighted and fearless. He standardized his publications as to size and typography, printed its circulation frankly upon each, refused to send a lot of returnables to newsdealers to be counted as circulation and then redeemed, made standard rates and kept to them, gave his editors a free hand and allowed no commercial considerations to weigh against them. His instructions were to do things, worth-while things, to do them first and to do them best. His insight into fundamentals was remarkable, his decisions prompt and inflexible, but with all this force and positiveness there was nothing domineering about him. He shrank even from giving a reprimand and delighted to be the "Old Man" to the "House of Hill." His informal communications were always signed in that way, the latest of these, accompanying a Christmas remembrance to each employee, containing the following characteristic expressions:

"The year 1915 is almost gone; it has brought more loss, suffering, death and despair to the human race than any other year of all recorded time, and yet, it has been good to us.

"We are all here—not a funeral or a serious illness in our ranks. Most of us are warm and eat regularly—Allah be praised!

"Most people dislike to get a bill at this time of the year, but here's one that you need not pay, so we think it will be welcome.

"With it goes a 'thank you' for every little item of service you have furnished this past year which has gone to make up the million-dollar mosaic that this company has made out of all our little items of service combined.

"If your heart and mind be charged with as much good-will, love and respect for the Hill Publishing Company as the institution has for you, the next year will be comfortable and happy for the whole works—big wheels, little wheels, case and fob."

As an engineer Mr. Hill devoted much thought and talent to the mechanical department of the business, and the twelve-story building which he has just erected and the model printing and binding plant comprising so many of his own ideas and inventions will be a monument to his engineering skill as the organization which the building houses is to his executive ability.

Mr. Hill was married in 1882 to Emma B. Carlisle, who, with one daughter, survives him. He was a member of the Engineers' Club, the Railroad Club and the Campfire Club, charter member and vice-president of the Machinery Club of New York, the Essex County Country Club, president of the McGraw-Hill Book Co., first president of the New York Trade Press Asociation and a member of the American Society of Mechanical Engineers, of which society he was one of the representatives on the advisory committee asked for by Secretary of the Navy Daniels. Almost his last activity was devoted to this work, upon which he had spent, at Washington, several days of the preceding week. He was a genial man, fond of companionship and with an endless fund of good stories, but social life and club life had little attraction for him, and his two chief interests were the enterprise he had created and in which he took such pride, and his home.

The esteem in which he is held by his associates is evidenced by the inscription placed above a marble fountain donated by the employees to the new building:

"Within this monument to independence, truth and service in engineering journalism the employees of the Hill Publishing Company have placed this tablet—an appreciation of the man and employer, John A. Hill."

Editorials

The Conquering of Corrosion

If one were asked to name the factor the elimination of which would be of the most benefit to the power plant, corrosion would be one of the first to come to his mind. If pure silver would not pit, it would pay to use it for condenser tubes in many cases where renewals are frequent. The pitting of tubes in boilers and heaters is a source of constant expense and danger. The weakening of sheets and stays has reduced the resisting power of many a boiler to the point where explosion has occurred. Piping requires constant renewal, steel stacks suffer, wrought tubes are avoided in economizers—all on account of corrosion.

But the power plant is only one small field. In bridge and structural engineering, railroading, wherever metals, especially iron and steel, are used in exposed situations, this silent combustion of expensive material in positions where unsuspected deterioration to the point of yielding may be enormously costly in lives and property and interruption to service is constantly going on. It would seem therefore that here is a field to which all the research facilities at the disposal of engineers could be profitably directed. The recent symposium of the Faraday Society on the subject was somewhat disappointing, owing in part doubtless to the exceptional times, but also perhaps to a general discursive attack upon a subject that will be mastered only by systematic detailed search into its methods and minutiæ and the accumulation of facts upon which hypotheses to be verified or disproved by further experiment may be based. The general effect of the symposium is favorable to the electrolytic theory and points to electro-chemistry as the most promising force available for the attack.

Here is another subject pregnant with possibilities for "the advancement of the engineering arts and sciences in all their branches" and broad enough to receive the consideration of the administrators of the Engineering Foundation instituted by Ambrose Swasey for this purpose.

Centralization Has Its Limits

Samuel Insull, president of the Commonwealth Edison Company of Chicago, is regarded by many as the foremost advocate of central-station service. His advocacy of centralization in power generation and of interconnection among distribution and transmission systems is closely identified with his great and deserved reputation as a captain of industry. When such a man concedes that there are limits to practicable centralization, as Mr. Insull did at the recent annual banquet of the Alumni Association of the Massachusetts Institute of Technology, it is indeed time for the humble engineer to take courage.

At this meeting a representative of *Power* listened with keen interest to an address on "Universal Electrical Supply," by the head of the Chicago company, who sketched in bold figures the economic saving possible by the centralization program, applying his inquiry first to Chicago and then to the whole United States. The speaker said that if all the power requirements of the country could be met by one system of production and distribution, including railroads, factories, residences, stores, etc., with illumination and motor service provided for all users of electricity as required, the 43,000,000 horsepower needed for separate operation would be reduced to 30,000,000 horsepower. "I am not suggesting a single system for the United States, however," said Mr. Insull; "that would be impossible, of course. I suggest a series of state-wide organizations where the density of use is sufficient and where all the energy of one territory would be operated under a series of systems. The saving in fuel consumption would be upward of 250,000,000 tons a year, or over $500,000,000 at an average price of $2 to $2.50 per ton. A universal system of electrical supply is as inevitable as day and night."

In speaking of the possibilities of steam-railroad electrification, Mr. Insull also said that the economic expediency of such a move must be determined by the railroads themselves. His business, he said, was that of a manufacturer of energy.

These two points—first, that a nation-wide system of energy supply is out of the question, and second, that the decision whether to purchase power in a case so important as that of the railroads must lie with the possible customer—ought to stimulate the operating engineer to the very finest level of professional accomplishment. In the past it has been easy for some advocates of central-station service to claim everything in sight and then some. Here the acknowledgment that the centralization of energy supply is an engineering problem, not perhaps in precisely this phraseology, but to all practical purposes, is a fair statement of the position of every engineer who seeks to serve the world with power at the lowest cost. Mr. Insull and his associates naturally believe that in the vast majority of cases the service of the central station is the most economical for the buyer of energy. An immense industry has been built upon this idea, but let us all realize that nothing in the central-station advance eliminates the need of adequate analysis in studying to find the limitations of centralized energy supply. It is up to the operating engineer to make his great competitor show the plant owner in every case just what his costs will be if he purchases service and to satisfy himself and his chief whether the results of competent engineering in the existing plant will win the day over the outsider.

Index to Last Volume

The index to Vol. 42, the second half of 1915, is about ready and will be mailed to all that are on the list of those wishing to receive the indexes regularly. All subscribers that have not previously notified us of their desire to have the indexes should so advise us and they will be mailed to them hereafter without further request while they continue to subscribe to *Power*.

Correspondence

Behavior of Foreign Gases in Refrigeration Plant

I believe I understand Mr. Fairbanks ("Decomposition of Ammonia and the Chances of Explosions," Nov. 23 issue) right when he says that by allowing an ammonia condenser to stand for a short time with the water running over or through it, the lighter gas will come to the top, when it can be drawn off. Take, for instance, air, which sometimes gets into the system. Air is heavier than ammonia gas, yet it can be purged off at the top of the condenser. A plant, assume, is running as usual; permanent gas is forming in the condenser and stays there because it will not condense and run out at the bottom as does the liquid ammonia.

Shut down the compressor or generator and allow the condenser to stand for a short time with the water flowing over it. While standing, it cools, condensing the ammonia that is mixed with the permanent gas; as the ammonia liquid leaves the top of the condenser, it gives room for this permanent gas to rise. However, as the pressure is decreased, this permanent gas expands, occupies more space and will continue to expand as long as the pressure is reducing. If there is enough permanent gas in the condenser and the pressure is high enough, the gas will keep the ammonia compressed until it liquefies. Assume that there is enough permanent gas in the condenser to fill only the top pipes. Under working conditions this would be mixed with ammonia gas and would occupy possibly four or five of the top pipes. Most of the ammonia gas will be condensed as before, but not as much of it, because the purer vapor condensing in the bottom pipes will reduce the pressure so rapidly that all the ammonia mixed with the permanent gas will not have time to condense.

This is the reason why, when the condenser contains a large amount of permanent gas, the latter will give almost a steady blaze as it issues from the purge valve when ignited, while when there is a small amount, as it issues it gives a flickering blaze and is difficult to keep lighted; there is a greater percentage of ammonia gas mixed with it.

As we purge the condenser, allowing the permanent gas to escape, the pressure is lowered below the condensing point or boiling point, the liquid ammonia in the bottom of the condenser or in the receiver will boil into gas and tend to keep up the pressure. However, only enough will turn into gas to maintain the pressure, and as the liquid boils the gas rises in the condenser, forcing the permanent gas to the top and out at the purge valve.

I believe most of the permanent gas found in a compression plant results from the distillation of the oil used in the compressor cylinder. In the absorption plant I believe it comes from the water.

In regard to Mr. Rice's article, "Operating Variable Temperature Refrigeration System," in the issue of Nov. 23, I agree that his plant is different from the ordinary. An 84-deg. F. discharge temperature is much lower than usual, and I take it that he must have cheap power or high-priced water, or both, to warrant running at that temperature. If he will carry the discharge between 180 and 220 deg. F., he will find that it will take much less power to do the same amount of refrigeration. More water will, of course, be required.

Take a card from the compressor with 84-deg. F. discharge temperature and one with the discharge at 220 deg. F., both with the same suction pressure, and observe the difference in the mean effective pressure. Mr. Rice does not need water in the jackets with an 84-deg. F. discharge temperature; if it is a double-acting compressor, the water will freeze in the jackets.

Winslow, Ariz. GEORGE J. TROSPER.

Breakage of Fan Blades

In the Nov. 16 issue, page 694, William A. Dunkley describes the breakage of fan blades and also the conditions under which the fans were operating.

I have had similar experiences, and a hint as to how these troubles were overcome and a suggestion as to the causes might prove of some value. Investigation of several cases showed that the metal of the blades had suffered crystallization, and the quality of the steel was at first questioned. The blades were replaced by material of known quality, but with no improvement, and it was

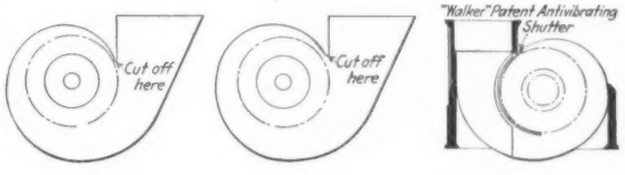


Fig. 1 Fig. 2 Fig. 3

VARIOUS DESIGNS OF CUTOFF

therefore concluded that the breakage was caused by vibration created by the moving air.

The fans that broke were very noisy, while the quiet-running ones gave no trouble. A small fan running at a comparatively low peripheral speed is usually quiet, but at high peripheral speeds, unless the design is correct, will invariably give trouble. The speed of the fans described by Mr. Dunkley would seem excessive, and it is believed that the substitution of straight blades for the curved ones, as suggested, would afford no improvement. Rather than attempt to build a wheel to resist the strain, the proper way is to try to remove the cause. In designing centrifugal pumps it is always the aim to pass water through without shock and without breaking the flow, and although air is elastic, fans should also be designed to pass air through with as little shock as possible, especially when operated at high peripheral speed, as the higher the speed the greater will be the impact of the air.

In many fans the point of cutoff on the casing is too sharp and too close to the wheel, resulting in a sudden

chopping off of the air as each blade passes, producing a hammer-blow effect, and this going on continuously must sooner or later either crystallize the blades or loosen the rivets. The better way is to avoid a sharp-edged cutoff, Fig. 1, and to allow a reasonable distance between it and the wheel, as in Fig. 2. This has been tried and found to be an improvement, resulting in quiet running and reduced strains on the wheel, and the distance between the cutoff and wheel can be increased considerably without affecting the output from the fan appreciably, and the radius of the cutoff, as shown in Fig. 2, can also be made quite large without detriment.

This detrimental effect of a sharp cutoff was realized many years ago by some of the earlier builders of large Guibal type of mine fans. While the peripheral speed was not great enough to cause noise or vibration, the jerk caused as each blade passed the cutoff resulted in many broken fan shafts and wheels. To obviate this trouble, Waker Bros., of England, introduced an adjustable V-shaped cutoff in the form of a sliding shutter, Fig. 3, the idea being to cause the air to be sent off gradually. The shutter was also adjustable around the periphery of the wheel in order to find the best operating position.

The following is an extract from a paper read by Charles H. Higson before the Manchester Geological Society in 1894:

> The invention and introduction of this shutter followed the erection of three Guibal fans for ventilating a portion of the Metropolitan Underground Railway about 1886. When the fans were set to work the pulsation or vibration of the large volume of air discharged was so great that it caused a vibration of the windows, doors, etc., of the surrounding buildings, so that an injunction was obtained against the railway company, compelling it to stop one of the fans.
>
> It occurred to the makers to incline the lower edge of the shutter instead of making it parallel with the axis of the fan, so that the waves of air might be broken up or at least reduced. Ultimately, the shutter was made like an inverted V, and this was found to be completely successful. Reducing shaft breakage was a still more important advantage gained by its application. Even though made unusually strong in proportion to the horsepower transmitted through them, they frequently break. This breakage of fan shafts and the loosening of bolts and rivets are to be attributed to the excessive vibration. This vibration is caused by the too-abrupt cessation of the delivery of the air from the fan vanes, or blades, as they pass the discharge opening, and for this the shape of the cutoff or slide is responsible when the delivery of the air is abruptly terminated.
>
> While discharging the air, the pressure is against the front of the vane, but immediately after the vane passes the cutoff the load upon it is suddenly removed, and the pressure, owing to the vacuum within the casing, is instantaneously reversed, and a rebound upward of the previously depressed blade takes place. The effect is communicated throughout the whole of the fan and to the shaft also, and as each blade represents a powerful lever, the momentum of the blow or jerk becomes serious on reaching the shaft, and a dangerous tremor or vibration is set up.

Union Bay, B. C. FRANK SANFORD.

The Lubrication of Bearings and Cylinders

F. L. Fairbanks' method of boring a cylinder and leaving the toolmarks to act as oil reservoirs (*Power,* Dec. 7, p. 805) is used by one well-known engine company of the Middle West. We have two of this company's engines on a cross-compound two-stage air compressor. The cylinders, as well as the guides, are bored out with a round-nosed tool making about three revolutions to the inch for the finishing cut and left as the tool finishes them, no polishing being done. The lubrication is excellent, and the grooves, being broad and rounded, do not fill with carbon, as I believe a narrow, sharp groove would.

I would like to see the wedge-screw adjustment for bearings in known increments of 0.002 in., as advocated by Mr. Fairbanks, put into general use. It would remove much guesswork and avoid the trouble that usually accompanies it. On our quarter-boxes we use screws with eight threads to the inch, setting up tight and then slacking back one-quarter-turn. This gives satisfactory, but not always uniform, results. A. A. BLANCHARD.

Ringwood Manor, N. J.

A Case of Reversed Polarity

Things had been going from bad to worse. The boiler plant was too small to begin with and so was the refrigerating system. When they began to run short of steam and the temperatures began to climb in the coolers, the management blamed the engineer. Finally a consulting engineer was called in. He ordered several expensive and radical changes without helping things very much.

One day he and his assistant decided to key up the engine, choosing the noon hour for this work. When they came to start, however, the generator failed to build up. They sweated, figured and experimented without results until it was time for the shop to start. The superintendent came down and was told that the generator was in very bad condition; and, after a few more unsuccessful attempts, he was advised to send the men home, as it would be impossible to start until some batteries could be procured to magnetize the fields again.

The superintendent started away to send the men home, when the old engineer stepped up and volunteered to get the plant running in five minutes. The superintendent told him to go ahead. The engineer went back of the switchboard and changed a couple of connections, started the engine and, sure enough, the voltage built up, whereupon he threw in the generator switch and told the superintendent that he might go ahead with the work in the shop.

The engineer, who had kept discreetly in the background while the other two were working on the engine, had noticed what they had failed to note—that the pilot lamp on the switchboard was burning. This was connected across the armature leads of the machine, and as it was of normal brilliancy, he judged there must be normal voltage on the machine. He also noticed that the indicator on the voltmeter, which also was connected across the armature terminals, swung down in the corner in the reverse direction every time the machine was started. From this he concluded that the machine was reversed.

When he told the superintendent that the plant could be started in five minutes, he reasoned that as all the motors in the plant were shunt-wound, it would make no material difference if the current was reversed until such time as the polarity could be corrected. He therefore only had to reverse the voltmeter and ammeter connections back of the board so as to get the proper indications on the instruments.

It appears that when the consulting engineer had shut down the engine, he had failed to open the generator

switch first. There was a large motor in one department driving a fan, the momentum of which kept the motor running for a long time after the current was cut off. This caused a reverse current to flow from the motor back to the generator and through the series field of the generator in the reverse direction, thus reversing the polarity. Opening the generator switch first, before shutting down the engine, would have obviated this trouble.

This fan had originally been driven by a small engine that was still in place. This gave the engineer an idea for correcting the polarity of the generator. The engine flywheel and motor pulley being in line, he belted them together, hung a test lamp across two brush terminals of the motor and, after pulling the motor switch, started the engine. In a few seconds the test lamp lit up to a dull light, indicating that the voltage was not up to normal. By adjusting the speed of the engine the lamp showed the proper brightness. This speed of the engine was noted.

Passing to the engine room, he pulled the power switch, slipped pieces of heavy cardboard under each set of brushes to open the armature circuit, removed the fuses from the generator circuit and replaced them with 10-amp. fuse wire which he cross-connected to reverse the current through the shunt field. Then be brought up to speed the engine driving the motor and closed the main generator switch and the power switch. After a few moments he slowly opened the power switch to let the discharge due to the self-induction of the fields die out slowly. Then he removed the cardboard from under the brushes on the generator, replaced the original fuses and started up the engine.

As he expected, the voltage came up in the right direction this time, and it was necessary only to reverse the instrument connections at the back of the board to bring everything back to normal. THOMAS G. THURSTON.

Chicago, Ill.

City Boiler Inspection Poor

We are told that cities that have boiler inspection departments are not in need of state supervision. At times this may be true, as in Detroit, where the law is strict and the supervision intelligent.

I observed an interesting instance of the careless kind of "inspection," showing the possibilities of dangerous abuse through gross ignorance or willful neglect on the part of the one at the head of the "boiler inspection" department of a city of about 50,000 inhabitants.

I learned that in a theater with seating capacity of 1,700, two 42-in. by 12-ft. tubular boilers would probably have to be replaced this year, and I called to see the conditions. The boilers were in the basement, just under the stairs leading to the balcony. The gravity return system was used, feeding through the blow-off, with make-up water from the city water supply. Each boiler had a 5-in. steam outlet with a vertical nipple about two feet long to an angle valve with horizontal stem just under the ceiling. The main steam line was 5 in., and about 6 ft. beyond the further boiler a 1½-in. pipe led toward the front, and at the end of this pipe was a 1½-in. ball-and-lever safety valve, the only one used. There was one provision for safety—a wire to try the safety valve from the floor. Without this the attendants would not have known whether or not that valve worked, as the walking of the audience on the stairs above jarred the weight toward the end of the lever. The caretaker and engineer who had been there three years had never heard the valve blow except when trying it.

The engineer did not like the layout, and told me that some time ago he had a steam coil give out when operating one boiler. He pulled the fire and closed the steam valve, but the brickwork was hot enough to cause a rise in steam pressure so that he had to crack the valve, in spite of the broken coil, to prevent excessive steam pressure. I suggested feeding and blowing off, but he told me that the steam pressure was soon above the city water pressure, and in the absence of feed pump or injector, he could not supply any water.

In spite of these conditions there was a framed certificate still in force, and signed by the city boiler inspector, giving the plant the official approval of the only department whose duty it is to prevent such conditions.

I am glad to say that as soon as these conditions were called to the attention of the owners, they had an insurance company inspector look over the installation, with the result that new boilers have been put in in accordance with the A. S. M. E. code.

Bay City, Mich. JOSEPH NELSON.

The Power Consumption of Ammonia Compressors

In his comment on Mr. Anderson's article, "Experiences of a Refrigerating Troubleman," in the Sept. 7 issue, A. G. Solomon in the Dec. 7 issue expresses his doubts as to the ability of the machine to operate under a back pressure of 60 lb., as stated by Mr. Anderson. From the assertions made by Mr. Solomon one would be led to the conclusion that the power required to operate the ammonia compressor increases with the suction pressure. This is not so. The capacity of the compressor varies directly with the suction pressure, but the power consumption does not. If the suction pressure is increased until it is equal to the condenser pressure, there will be no work of compression and the power required to drive the machine will be only that required to overcome the friction of the moving parts, lift the valves and force the gas through the passages. At the other extreme, or when the back pressure is absolute zero or a perfect vacuum, the power consumption will be only the amount less than in the case just stated by the amount required to lift the valves and that required to force the gas through the passages.

Somewhere between these two extremes must be the maximum power consumption. Approximately, this will be found when the suction pressure is one-fourth of the condenser pressure. It must be remembered that the power consumption of the compressor is determined by the mean effective pressure in the cylinder, which in turn depends on the initial suction pressure and the difference between the suction and condenser pressures, and is a function of two factors instead of one, as is the case with capacity, with which it is confused at times.

Fig. 1 illustrates this graphically. *A*, *B* and *C* are the adiabatic-compression curves respectively for 15, 30 and 60 lb. absolute suction pressure. I have used the exponent 1.3 instead of 1.405, which is the exponent for perfect adiabatic compression, because this coincides more nearly to operating conditions, as the jacket water re-

moves some of the heat of compression. A comparison of the curves at different condenser pressures will show that the power consumption does not vary as the suction pressure.

The mean pressure of curve *A* at 100 lb. condenser pressure is 35.8 lb. For *B* at the same condenser pressure, the mean pressure is 41.55 lb. and for *C*, 31.05 lb. While the suction pressure of *C* is four times that of *A*, the power consumption is only 86.7 per cent. of that of *A*. While the suction pressure of *C* is twice that of *B*, the power consumption is only 74.7 per cent. The mean pressures for *A*, *B* and *C* at 120 lb. condenser pressure are 40.3, 49.05 and 43.55 lb. respectively.

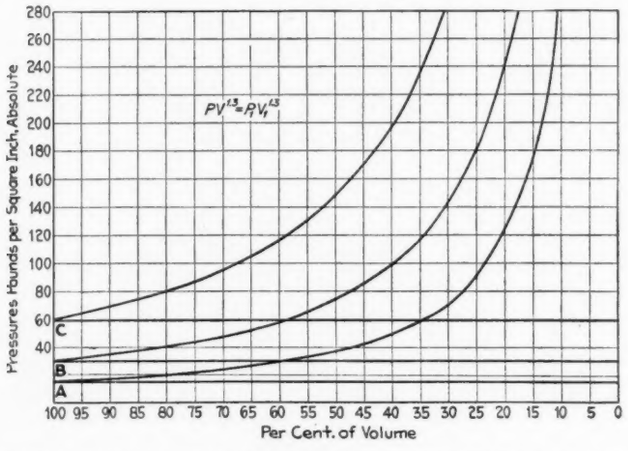


FIG. 1. ADIABATIC-COMPRESSION CURVES FOR 15, 30 AND 60 LB. ABS. SUCTION PRESSURE

The power consumption at 15 lb. suction pressure is still nearly as great as that at 60 lb., and the power consumption at 60 lb. is only 88.8 per cent. of that at 30 lb. The mean pressures at 140 lb. condenser pressure are 44.1, 55.55 and 54.5 lb. respectively for *A*, *B* and *C*. The power consumption at 15 lb. suction pressure is now 80.9 per cent. of that at 60 lb., and the consumption at 60 lb. is 98.1 per cent. of that at 30 lb. The mean pressures at 160 lb. condenser pressure are 47.5, 61.4 and 64.2 lb. respectively for *A*, *B* and *C*, corresponding to a power consumption of 72.5 and 95.6 per cent. of that at 60 lb. suction pressure for 15 and 30 lb. respectively.

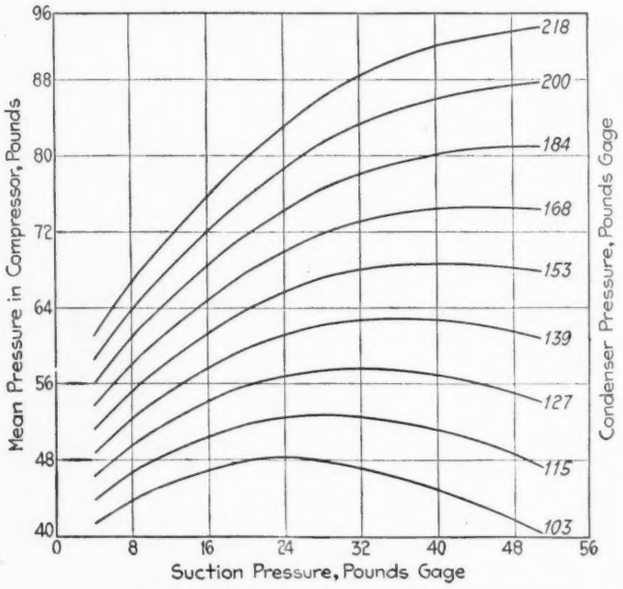


FIG. 2. VARIATION OF MEAN EFFECTIVE PRESSURES WITH DIFFERENT SUCTION PRESSURES

From this one can see that increasing the suction pressure from 15 to 60 lb. (0 to 45 lb. gage) at 160 lb. condenser pressure (145 lb. gage), the power consumption is increased only 38 per cent. while the suction pressure is increased 400 per cent.

Increasing the suction pressure 200 per cent. from 30 to 60 lb. (15 to 45 lb. gage) at the same condenser pressure increases the power consumption only 4.6 per cent. Increasing the suction pressure from 30 to 60 lb. at 140 lb. condenser pressure (125 lb. gage) reduces the power consumption 1.9 per cent., while the suction pressure is increased 200 per cent.

MEAN PRESSURE IN COMPRESSOR AT DIFFERENT SUCTION AND CONDENSER PRESSURES

Refrigerator Pressure	Refrigerator Temperature	Top Line, Condenser Pressure; Second Line, Condenser Temperature, Deg. F.								
		103 65	115 70	127 75	139 80	153 85	168 90	184 95	200 100	218 105
4	—20	41.46	43.91	46.34	48.77	51.23	53.68	56.11	58.54	60.99
6	—15	42.72	45.38	47.90	50.74	53.40	56.08	58.86	61.40	64.08
9	—10	44.40	47.38	50.33	53.29	56.25	59.20	62.16	65.14	68.09
13	— 5	45.86	49.15	52.42	55.70	58.97	62.25	65.53	68.81	72.08
16	0	46.94	50.56	54.16	57.78	61.40	65.00	68.62	72.22	75.84
20	5	47.74	51.73	55.70	59.68	63.67	67.66	71.62	75.61	79.61
24	10	48.04	52.40	56.77	61.13	65.51	69.86	74.24	78.59	82.97
28	15	47.88	52.67	57.44	62.23	67.02	71.81	76.60	81.39	86.18
33	20	47.08	52.30	57.53	62.75	67.98	73.23	78.46	83.68	88.91
39	25	45.06	51.34	57.05	62.75	68.46	74.17	79.88	85.58	91.29
45	30	43.16	49.71	55.92	62.14	68.35	74.56	80.77	86.98	93.19
51	35	40.52	47.26	54.02	60.76	67.52	74.28	81.02	87.78	94.52

With increased condenser pressures the rate of decrease in the power consumption in proportion to the increase of suction is not so apparent. It is well to remember that for every condenser pressure there is a corresponding maximum suction pressure above which the power to drive the compressor decreases.

The curves in Fig. 2 illustrate this graphically and are based on the figures in the accompanying table, taken from Siebel's "Compend of Mechanical Refrigeration," which credits them to the De La Vergne Co. From these curves it will be seen that maximum mean effective pressure, and consequently the power required at 103 lb. condenser pressure, is obtained at about 24 lb. suction pressure. As the suction pressure is increased above this point, the power required decreases until at 51 lb. the mean effective pressure is less than that at 4 lb. At 115 lb. the maximum is 30 lb., at 127 lb. about 33 lb., etc.; in fact, at the higher condenser pressures the power consumption remains practically constant over a wide range of suction pressures, as may be seen from the curve corresponding to 153 lb. condenser pressure. Here there is only a fraction of a pound variation in the mean pressure, while the suction pressure varies from 32 to 50 lb.

Chicago, Ill. THOMAS G. THURSTON.

Groaning in Steam Pump

I have a duplex boiler-feed pump that has lately been thoroughly overhauled—steam and water cylinders rebored, new rods, and steam valves faced—but I can't keep it from groaning, even with from 2 to 3 pints of good cylinder oil in 10 hr. It supplies water for one 60-in. by 18-ft. boiler. Suggestions will be appreciated.

Keokuk, Iowa. E. BLONDET.

Details of First Government Built Diesel Engine

SYNOPSIS—The structural details such as bearings, cylinders, cylinder heads and pistons are described, the valve timing is given, and the control features are discussed. The engine is rated at 2,500 hp. in six cylinders and operates on the two-stroke cycle.

The Nov. 23 issue contained a brief outline of the first Diesel engine built by the United States Government, which is one of two for the fuel ship "Maumee." The November issue of the "Journal" of the American Society of Naval Engineers contains a very complete description of this engine in a paper by Lieut. C. W. Nimitz. The following details are taken from this source:

Each of the two engines will develop about 2,500 hp. at 130 r.p.m. and is of the two-stroke-cycle six-cylinder crosshead type. Referring to the illustrations, it will be seen that the scavenging pumps are mounted on the outboard columns of the even-numbered cylinders and are driven by links and beams from the main crossheads. Each scavenging compressor is double-acting and draws the air from both sides of the piston through the outboard side of the scavenging cylinder and then through 12 flat-disk suction valves, six for the top and six for the bottom of the compressor. The air, after compression to about 8 lb., passes through 12 discharge valves and two coolers to the receiver. The suction and the discharge valves are assembled in six units, each consisting of two suction and two discharge valves mounted on one stem. By removing the valve bonnets the valve units are readily accessible and easily removed.

Directly under each scavenging compressor and driven by the same crosshead are two pumps. These supply fresh water for cooling the pistons, lubrication for the main crankpin crosshead and thrust-block bearings, salt water for cooling all the engine parts except the pistons and service for bilge and sanitary systems.

AIR COMPRESSORS AND FUEL PUMPS

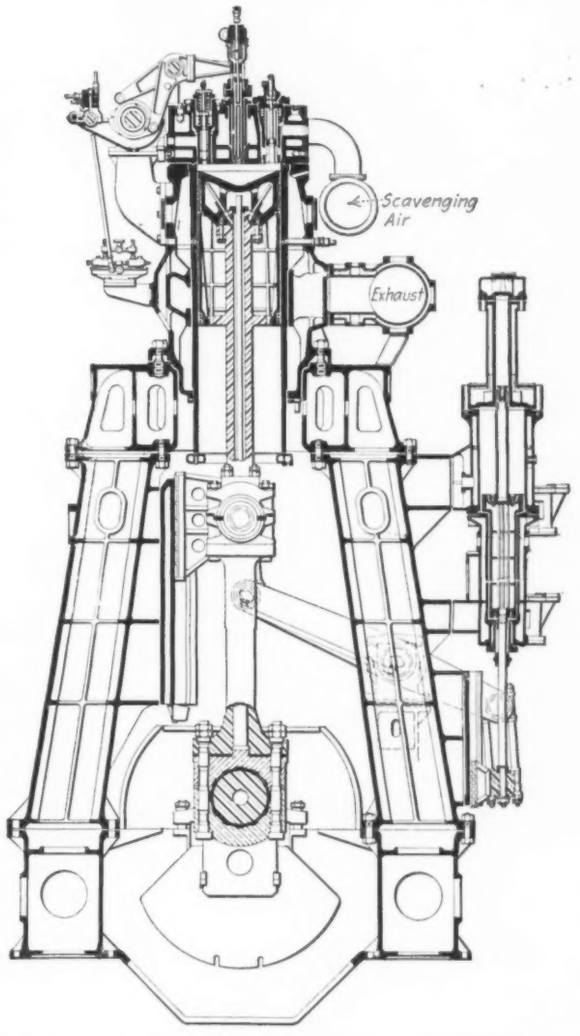
The high-pressure air compressors are mounted on the outboard columns of the odd-numbered cylinders and are driven from the main crosshead by links and beams. They are of the three-stage tandem-piston type, the low-pressure stage being double-acting, while the middle- and high-pressure stages are single-acting. Each compressor has on its forward side an intercooler which contains the cooling coils for all three stages. The piston and discharge valves of the low stage are of the flat-disk type, while those of the higher stages are of the poppet type. The three compressors deliver to a common pipe which conveys the air through separators to the spray-air bottle, from whence it leads to the fuel-valve bodies in the cylinder heads. The spray-air bottle has an overflow valve, whereby air in excess of that necessary for spraying is passed into a bottle for storing the starting air. Two of the compressors are sufficient for the injection air, and the third serves as a reserve.

A small fuel-oil supply pump is attached to the No. 1 outboard column and is driven by the beam. This maintains the fuel supply from the ship's bunkers to the engine-room tank. The fuel-oil-measuring or cylinder-supply pumps are six in number, one for each cylinder. Two are contained in one body, and all the pumps are driven by eccentrics from the main camshaft. Each fuel pump has a mechanically operated suction valve and two discharge valves in series. The speed and power of the engine are controlled by varying the period of opening of the suction valves and therefore the quantity of fuel pumped to each cylinder.

In starting, compressed air at about 650 lb. is admitted from the starting bottles to those cylinders whose cranks are in the proper position for running in the desired direction. After the engine begins to turn, starting air is admitted to each cylinder from 10 deg. past the top center to 85 deg. past the top center, until the engine has attained sufficient speed for fuel admission. When the engine is running normally, fuel is admitted to the cylinder from 2½ deg. before the top center is reached to 37½ deg. past the top center. Prior to the fuel admission, clean air from the scavenging receiver has been compressed in the working cylinders to about 450 lb.

The exhaust ports are uncovered 35 deg. before the bottom center is reached, and 2½ deg. after the exhaust ports start to be uncovered two scavenger valves in the cylinder head are opened by the camshaft, admitting fresh air at 7 or 8 lb. to the cylinder for scavenging. The exhaust ports are again covered by the piston at 35 deg. past bottom center, and compression begins. The scavenger valves remain open until 31½ deg. after the exhaust ports are closed by the piston. Compression now occurs until 2½ deg. before the top center, when the fuel valve opens.

Concerning the structural details, the engine bedplate is in three cast-iron sections bolted together, each section containing three main bearings consisting of a flat-bottom cast-iron piece supported in the bedplate saddle, a lower main bearing, brass, cored for water circulation and capable of being rolled out of the saddle without the removal of the



SECTION THROUGH CYLINDER AND AIR COMPRESSOR

crankshaft, and a flat-topped upper bearing brass, cored out for stiffness and lightness. The binding cap is of forged steel, and the bearing brasses are lined with a white metal consisting of 80 per cent. tin, 15 per cent. antimony and 5 per cent. copper, this being somewhat harder than the Navy Standard bearing metal.

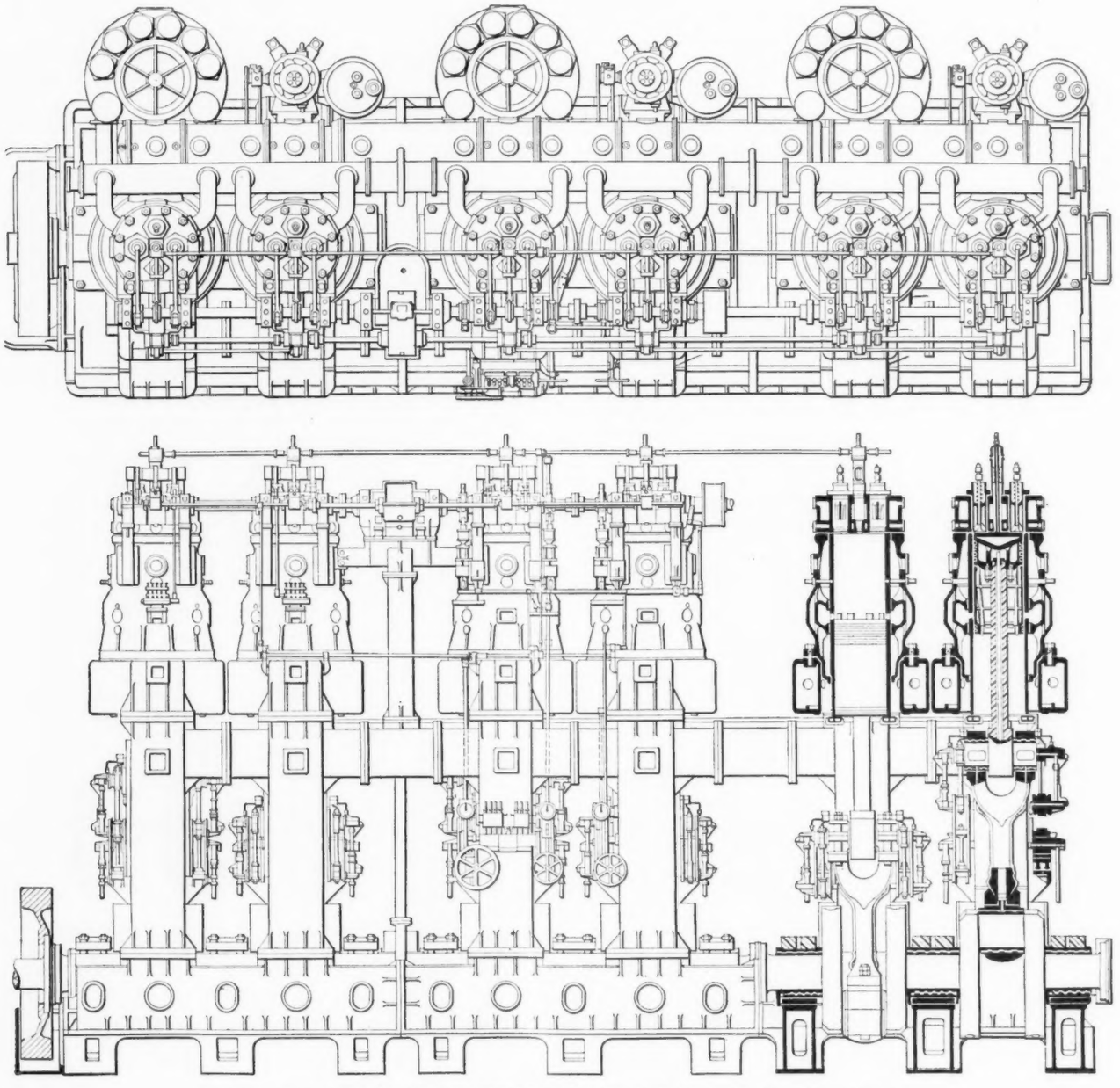
The main crankshaft is in three interchangeable sections approximately 15½ in. diam., and is made of special forgings having a tensile strength of 71,000 to 78,000 lb. and an elongation of 18 to 20 per cent. The sections are bored hollow and drilled for the forced-lubrication system. The sequence of cranks (turning outboard) are numbers 6, 1, 4, 5, 2 and 3.

The piston rod is forged steel and is bored hollow for the passage of the fresh water to and from the working

piston. The piston is divided into two parts—the working piston, which consists of a specially lined casting cored for water circulation and ribbed for strength, and a lower iron casting, which is bolted to the piston rod. The two sections are not bolted to each other, although both are secured to the rod. The working piston is dished on top and is machined with greater clearance at its top than at its bottom. It carries six cast-iron snap rings varying in width from the top to the bottom, the upper rings being given more clearance than the lower ones on account of the greater heat. The lower part of the main piston merely serves as a guide and has two cast-iron snap rings at the bottom to prevent the escape of gas into the engine room.

Fresh water coming up from the rod enters the central compartment of the piston, passes out toward the side through cored passages at the top of the piston and finally reaches the concentric space in the piston rod through four pipes set at 45 deg., returning from the highest point of the water space and thus insuring a flow of water along the hottest parts of the piston. This method of conveying the cooling medium to and from the piston has the advantage of simplicity, but it also has the disadvantage of heating the water entering the piston by that just leaving the piston, and vice versa.

The main cylinder is made up of two parts—a cast-iron jacket carrying the exhaust belt and a plain cylindrical liner of special cast iron. The space between the cylinder jacket and the liner forms the water jacket for the salt cooling water. The top of the liner is securely held in place by the cylinder head, while the lower end is free to expand through the stuffing-box in the bottom of the jacket, which prevents salt-water leakage. The surface of the liner passing through the tight fit at the exhaust belt has several shallow grooves, whose object is to collect any slight water leakage. The grooves are about ¼ in. deep and ½ in. wide, and are connected to pet-cocks on the outside of the cylinder jacket. These are kept open and act as leak indicators.



PLAN, ELEVATION AND PARTIAL LONGITUDINAL SECTION OF ENGINE

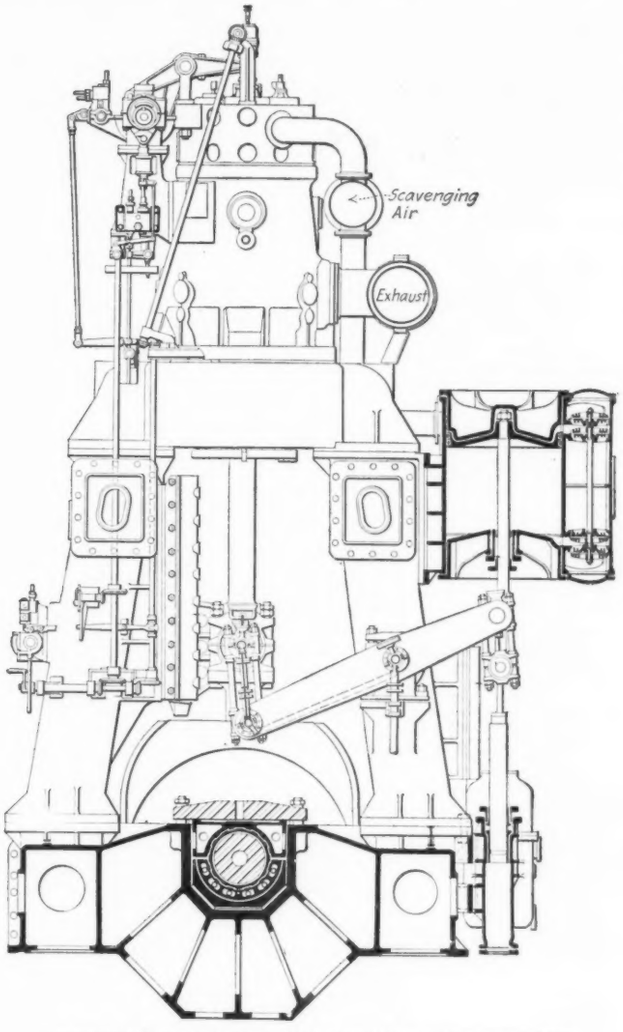
The cylinder head is bolted to the cylinder by 12 studs. the joint between the head and the liner being made tight by a thin copper gasket. The head has five openings to receive the valve cages. The center one is for the fuel valve, the two largest openings on either side are for the scavenging valves; the inboard opening is for the cylinder-release valve, and the outboard opening is for the air-starting valve.

Three types of cylinder heads are being tried on the first engine to be constructed. One type, which is shown in the general arrangement, is a special iron casting in one piece, with the head divided into two compartments for cooling.

The water from the cylinder jacket is bypassed around the cylinder-head joint into the lower compartment of the head, through which it must all go before rising to the upper compartment. A cast-steel sleeve in the center of the head receives the spray-valve body. Another type of head being tried is of the same design, but has a much thinner bottom and is made of manganese brass. The third type consists of a cast-iron upper story with a forged-steel bottom, the latter being machined out for water circulation.

The fuel-spray valve located in the center of the head consists of a cast-iron body housing a long forged-steel needle valve opening upward. This valve is opened by the camshaft and is ordinarily held shut by heavy springs. The compressed air for fuel injection is connected to the valve body at the top and maintains a constant pressure in the body, there being a safety valve in the air line at each cylinder.

The camshaft is on the inboard side of the engine and is in four sections, the first section carrying the cams for cylinders Nos. 1 and 2; the second, the governor, the cam for cylinder No. 3 and an eccentric for driving the fuel pump for cylinders Nos. 1 and 2; the third carries the cam for cylinder No. 4 and the gear that transmits the motion of the vertical shaft to the camshaft; and the fourth carries the cams for cylinders Nos. 5 and 6.



SECTION THROUGH SCAVENGER COMPRESSOR

The high-pressure air system of one engine consists of the three attached air compressors, the spray flask of about 5 cu.ft. capacity, the six starting-air flasks with a capacity of about 180 cu.ft., air separators, piping, release valves, etc. One auxiliary air compressor independently driven by steam, with a capacity equal to that of one of the attached air compressors, is also provided for charging the spray and starting flasks when all the air is gone.

The salt-water cooling system consists of two attached plunger pumps under the middle scavenger pump and an independently driven steam plunger pump, together with the necessary connections and piping. Both attached pumps have a common suction, and each is of sufficient capacity to supply the salt-water system at normal power. The salt water is discharged into a large main at the back of the engine beneath the floor-plate, from which a branch leads upward to the bottom of each intercooler for the high-pressure air compressors, and to the bottom of each cooler in the scavenger-pump castings. The main then continues around the forward end of the engine, where a branch leads upward on the outboard side of the main bearing cap. Continuing around to the inboard side of the engine under the floor-plate the main supplies a branch to the bottom of each ahead crosshead guide. A collecting main runs around the engine at the height of the cylinder base. On the inboard side it receives the return cooling water from the crosshead guides, and at the after inboard side it receives the return cooling water from the main bearing and thrust block. On the outboard side of the engine it receives the cooling water from the scavenger cooler.

Back of the engine all the water in the collecting main enters the bottom of the main cylinder jackets, two branches leading to each jacket. The cooling water leaving the high-pressure intercoolers of each compressor is led to the lower end of the jacket of the middle-stage air-compressor cylinder. From here it is forced upward into the jacket of the low-stage cylinder through two ferrules set partly into each cylinder at the joint. From the low-stage jacket the water enters the high-stage jacket through two bypasses around the cylinder joint, and from the high-stage jacket the water is forced into the high-stage cylinder head to two bypasses around the joint between the head and the cylinder. From the head of each high-stage cylinder the water is led into the exhaust-pipe jacket. This return water was originally forced into the aforementioned collecting main, from whence it entered the main cylinder jacket, but the heating of the compressors, due to poor circulation of the water, forced the change described. From the main cylinder jacket the water enters the cylinder head through a bypass around the joint between the cylinder and the head. After circulating through the lower and upper compartments of the head, the water enters the exhaust-pipe water jacket, and from here is finally discharged into an overboard discharge main.

FRESH-WATER COOLING FOR PISTONS

The fresh cooling water is drawn from a compartment in the double bottom, where it is cooled, to the piston, through a swivel joint on the after beam bearing, a pipe secured to the beam, another swivel joint on the crosshead end of the beam, the main crosshead, a nickel-steel pipe running up the center of the piston rod, and four collecting pipes reaching the highest part of the outer cooling space in the piston, as previously explained. From the piston rod the hot water reaches a discharge main back of the engine via links and beams, and the forward end of the crosshead, in a manner similar to that of entering.

A small copper pipe leading from the discharge side of each piston is led to the inboard side of column No. 2, where it delivers through a small pet-cock into a funnel. This affords the operator an opportunity to see at a glance whether the system is functioning properly, and he can also feel the temperature of the cooling water.

On the operator's platform is the maneuvering control wheel, which controls the starting, stopping and reversal of the engine by means of compressed air. This wheel also cuts off the fuel and spray air from the cylinders during maneuvering and until the engine is turning over in the desired direction. Above the maneuvering control is a dial on which a pointer indicates the running position of the engine.

On the forward side of No. 4 column is the fuel-control wheel, which governs the quantity of fuel pumped into each cylinder. The pointer and dial above the fuel control indicate in eight equal steps the quantity of fuel pumped, from a minimum to the maximum. Coming out from the shaft of the fuel-control wheel is the needle-stroke control which varies the stroke of the fuel-spray needle from maximum to minimum.

On the after side of column No. 3 is a hand cutout by which the engine can be instantly stopped. It operates to raise the suction valves of the fuel pumps, thus rendering them inoperative. Below this is the control for the high-pressure air supply, which regulates the opening of the suctions of the low-stage cylinders of the air compressors. The quantity and the pressure of the spray air is thus controlled.

The Annual Coal Production of the World is approximately one and one-half billion tons, of which amount the United States produces about 40 per cent. Pennsylvania is the largest producer of coal in the United States, West Virginia is second and Illinois third in tonnage.

DELEGATES AND ATTENDANTS OF THE CONVENTION OF THE MARINE ENGINEERS BENEFICIAL

M. E. B. A. Annual Convention

The forty-first annual convention of the Marine Engineers' Beneficial Association was held at Washington, D. C., during the week beginning Jan. 17. The Raleigh Hotel was the headquarters. Upward of 125 delegates attended. The several business sessions of the convention were held in the oak room of the hotel and conveniently located were the secretary's quarters and committee rooms.

Several important resolutions conducive to the welfare of the organization were introduced and, after discussion, were referred to the proper committees. Owing to the increased amount of business to be considered by the delegates this year, it was necessary to lengthen the hours of the sessions and to place a time limit on the speeches of the members. In this way considerable good work was accomplished with harmony and dispatch.

At the Wednesday morning meeting the following national officers were elected: Bruce Gibson, San Francisco, president; Charles N. Vosburgh, New Orleans, first vice-president; William C. Wilson, Philadelphia, second vice-president; L. C. Potteiger, Washington, third vice-president; George S. Grubb, Chicago, secretary; Albert L. Jones, Detroit, treasurer. The newly elected members of the executive committee include Robert L. Goelet, Norfolk; William S. Brown, Buffalo; Charles S. Follett, Seattle; and Cliff E. Shrodes, St. Louis. Clinton P. Thurston, of Norfolk, was chosen as trustee.

On Thursday morning at 10 o'clock the delegates and guests assembled in front of the hotel and marched to the White House to shake hands with President Wilson, after which the official photograph was taken, a reproduction of which appears herewith.

The Fire Fighters' organization of Washington gave a complimentary sight-seeing auto trip to the delegates and guests on Thursday afternoon.

On Thursday evening the ladies attended Keith's Theater, as guests of the supplymen.

The leading feature of entertainment was the smoker in the large ballroom of the Raleigh, given by the supplymen's association. More than five hundred were present, including many high officials from the Army and Navy Departments. The "New York Bunch" of entertainers furnished a program that was obviously appreciated.

At the meeting of the supplymen's association Monday morning a resolution was unanimously adopted to provide a general headquarters room for the entertainment of the delegates and guests, to be supported by the several firms in attendance.

At the supplymen's meeting on Thursday morning, George S. Norman, of the Dearborn Chemical Co., was reëlected president, and Charles A. Wilhoft, of the New York Belting and Packing Co., was continued in the office of secretary-treasurer.

Washington, D. C., was selected by the delegates as the the place for the next annual convention of the Marine Engineers' Beneficial Association, which will be held in January, 1917.

W. S. E. Holds Annual Dinner

About three hundred attended the forty-sixth annual meeting and dinner of the Western Society of Engineers held on the evening of Jan. 12, at the Hotel Sherman, Chicago. Dr. Edwin H. Lewis, Dean of Lewis Institute, was toastmaster. The secretary read abstracts of the annual reports, and short talks by the retiring president, W. B. Jackson, and the president-elect, Bertrand E. Grant, preceded the address of the evening on "Universal Electricity Supply," by Samuel Insull, president of the Commonwealth Edison Co. The speaker held up a universal central-station system as a solution of the national problems of city growth and the depletion of the coal supply. If it is desired to conserve the coal deposits, to save capital and eliminate duplication of investment, to supply electrical energy for the lowliest citizen of the community, the only possible way, in Mr. Insull's opinion, was to marshal together all the energy required. Under these conditions the energy can be produced at the least possible cost and sold at a low price, thus making it possible to carry the advantages enjoyed by the manufacturer and householder of the largest cities to the smallest villages, enabling manufacturers to operate there to advantage and making it possible for employees to live in more favorable surroundings, with plenty of light and air.

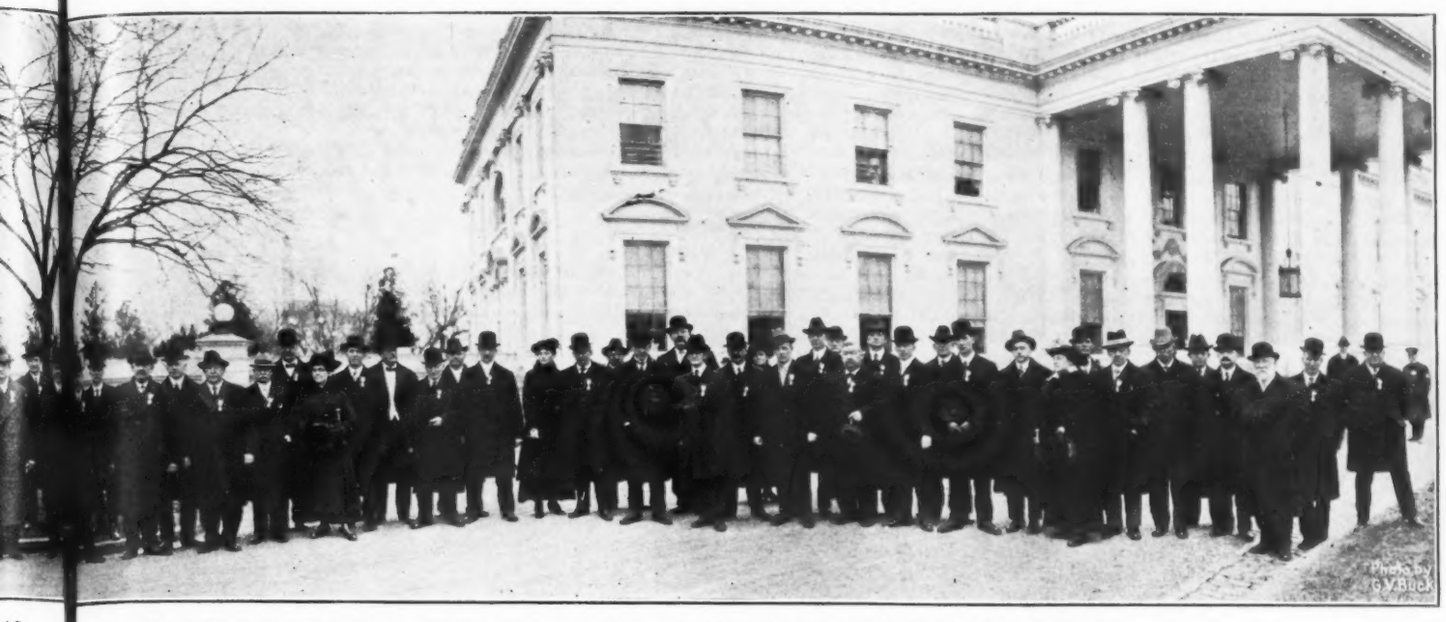
Owing to the fraternal and democratic spirit displayed, the meeting was a great success. Youthful or baby pictures of the various past-presidents were thrown upon the screen, numerous cartoons of various members drawn by brother members were in evidence, and even the songs were prepared by home talent. Music by the Commonwealth Edison orchestra, assisted by the choral society of the People's Gas Light and Coke Co., was an enjoyable feature of the program.

Chanute medals were awarded for the best three papers presented to the society during the year 1914—to Andrew Allen, for his paper on "Engineering Opportunities of Our Coal Mining Fields"; to N. M. Stineman, for his paper entitled "Reactions in a Three-Legged Frame with Hinged Column Bases"; and to H. E. Goldberg, for a paper on "Arithmetical Machines."

The following officers, who had been previously elected, were installed: Bertrand E. Grant, president; Charles H. Cartlidge, first vice-president; Denny C. Roper, second vice-president; Frederick H. Newell, third vice-president; Carlton R. Dart, treasurer; Ernest McCullough, trustee; and W. B. Jackson, the incoming past-president on the board.

Erie City Boiler Board

An ordinance creating a board of boiler-license appeals and providing the manner of appointment and defining the duties and powers thereof, and another, defining the manner of appointment and the filling of the vacancies in the office of boiler inspector were recently passed by the council of Erie City, Penn.



ASSOCIATION AT WASHINGTON, D. C., AFTER RECEPTION BY PRESIDENT WILSON, JAN. 20.

Annual Meeting of Heating and Ventilating Engineers

The twenty-second annual meeting of the American Society of Heating and Ventilating Engineers was held at the Engineers Societies Building, 29 West 39th St., New York City, Jan. 18-20. The first day was devoted to registration and an informal reception up to 1:30, and the business session, consisting of a roll call, reading of minutes, reports, etc., including the appointment of tellers of election and nominating committee, was the order of the afternoon. Two papers were presented: "Steam Required for Cooking," by D. S. Boyden and others; and "Cost of Opening Streets for Pipe Trenches," by Prof. W. T. Verner.

Tuesday evening after the report of the tellers four papers were presented: "Heating and Ventilating Plant of the Waite High School," by S. R. Lewis; "Heating Industrial Plants," by J. F. Cyphers; "Heating the Commonwealth Edison Building, Chicago," by S. M. Bushnell; and "Office Building Costs," by G. W. Martin, followed by a discussion of radiation factors to allow for window leakage.

Wednesday morning, Jan. 19, the general theme was papers and discussions on "Air Leaks Through Windows," one paper being by S. C. Voorhees and H. C. Meyer, Jr., another by J. W. Whitten and R. C. March. "Recirculation of Air in a School" was treated of in a paper by Prof. G. C. Larson.

Wednesday afternoon A. K. Ohmes gave a description of the "Testing Institute of Berlin" and W. H. Driscoll a description of the "Heating and Ventilating Plant of the Equitable Building." "The Prevention of Corrosion in Pipe" was the title of a paper presented by F. N. Speller and the "Transmission of Heat in Warm Air Furnaces," by Prof. J. R. Allen. The annual dinner was held at the Hotel Astor in the evening.

The closing session, Thursday afternoon, Jan. 20, was devoted to three papers and the installation of the newly elected officers. The papers were: "Report on the New York State Ventilation Commission's Work During 1915," by G. T. Palmer; "Ventilation of Homes," Chicago Commission on Ventilation; and "Can We Standardize the Requirements of Ventilation," by J. J. Blackmore.

The newly elected president is Harry M. Hart; first vice-president, Frank T. Chapman; second vice-president, Arthur K. Ohmes; treasurer, Homer Adams; secretary, J. J. Blackmore. The meeting as a whole was one of the most profitable and enjoyable in the history of the organization.

Massachusetts Boiler Bill

A bill has been introduced in the Massachusetts Legislature providing for the establishment of a bureau of steam engineering and boiler inspection in place of the supervisory establishment now maintained as a department of the district police. In general the powers and duties of the present boiler-inspection department are transferred to the bureau by the bill.

An important feature is a provision for a chief inspectorship in the new bureau at a salary of $3,000 per year, with traveling and other necessary expenses added. The incumbent of this position is required to be a citizen of Massachusetts not over 45 years of age and is to have held a first-class engineer's license for at least 5 years, or to have served as a member of the present boiler-inspection department. Selection is by competitive examination, the governor being required to appoint, without confirmation by the council, one of the three applicants who pass the examination with a higher rating than 80 per cent.

The bill provides that all future appointments as inspectors of boilers in the bureau shall be made by the governor after competitive civil-service examination, applicants to be not over 50 years old and to hold a first-class engineer's license. The chief of the bureau is to act as chairman of the board of boiler rules. Examinations for certificates of competency as inspectors of boilers for insurance companies are to be uniform, and written if the applicant requests.

The deputy chief of the boiler-inspection department is to act as chief of the bureau pending the selection of a chief by examination and appointment. The bill has been referred to the committee on mercantile affairs and is listed as House Bill No. 312.

Sampling and Analyzing Flue Gases

As the analysis of flue gases tends to develop better methods of firing, which in turn reduce waste of fuel, the Bureau of Mines, Department of the Interior, in Bulletin 97, "Sampling and Analyzing Flue Gases," by Henry Kreisinger, engineer, and F. K. Ovitz, assistant chemist, just issued, presents for the benefit of those in charge of boiler plants and all other persons interested detailed information on methods of sampling and analyzing flue gases and on the utilization of the analyses in promoting boiler-room economy.

This bulletin is intended to be a companion to Technical Paper 80, "Hand Firing Soft Coal Under Power-Plant Boilers," and is written in plain and nontechnical language. Whenever possible, illustrations of apparatus and methods of handling have been used rather than elaborate descriptions.

The material presented is arranged in two parts. The first contains the description of the apparatus and the methods used in sampling and analyzing flue gases. The second gives experimental results obtained with the different methods of sampling and collecting flue gas that are recommended in the first part of the report.

Only simple apparatus and methods are considered, as they are accurate enough to show the large heat losses due to the use of too much air and are also accurate enough to indicate any incomplete combustion losses of economic importance. Without doubt the loss due to large excess of air is the greatest one in the boiler room and can usually be greatly reduced by making proper use of gas analysis. Before engi-

neers in isolated industrial plants can be induced to analyze for small traces of combustible gases, they must be taught how to analyze for carbon dioxide and they must learn to appreciate the great possibilities of reducing loss from large excess of air. Furthermore, in the face of the great difficulty of obtaining a fair average sample, it is doubtful whether more delicate apparatus for analysis and more refined methods would be of much advantage. Those who wish to obtain information on the more accurate methods of analysis of gases are referred to Bureau of Mines Bulletin 12, "Apparatus and Methods for the Sampling and Analysis of Furnace Gases," and Technical Paper 31, "Apparatus for the Exact Analysis of Flue Gas," which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 5c. each. Bulletin 97 may be obtained by addressing the Director of the Bureau of Mines, Washington, D. C.

This latter bulletin will be abstracted in "Power."

ENGINEERING AFFAIRS

The Eccentric Association of Firemen No. 56, New York City, held its twenty-first annual entertainment and ball at the Central Opera House, Saturday evening, Jan. 15. The program consisted of ten selected vaudeville numbers of a pleasing character, followed by dancing, also an exhibition four-hand Irish reel on the main floor. The attendance was probably a record breaker, numbering upward of four thousand.

The Detroit Engineering Society will be addressed on Friday evening, Feb. 4, by Walter N. Crafts, consulting engineer, Oberlin, Ohio, a member of the Cleveland Engineering Society, on "Recent Developments of the Electric Furnace." The lecture will be illustrated. On Friday evening, Feb. 18, Charles L. Weil, engineer for the Diamond Crystal Salt Co., St. Clair, Mich., will talk on "Notes on the Salt Industry."

The Minnesota Section of the A. S. M. E. recently elected the following officers: Charles W. Tubby, St. Paul, chairman; Prof. J. V. Martenis, University of Minnesota, Minneapolis, vice-chairman; Quincy A. Hall, St. Paul, secretary and treasurer. These, with the addition of Max Toltz, St. Paul, and Prof. W. H. Kavanaugh, University of Minnesota, Minneapolis, constitute the executive committee of the Minnesota Section. On Jan. 20, the Section will hold its annual banquet and dance at the University Club, St. Paul.

The Indiana Engineering Society will hold its annual meeting in conjunction with the Indiana Sanitary and Water Supply Association at Indianapolis, Feb. 3-5, with headquarters at the Claypool Hotel. The program of papers is as follows: "Specifications and Construction," H. A. Blunk, Martinsville, Ind.; "Concrete Sewer Construction in South Bend," W. E. Graves, South Bend, Ind.; "Compression Members for Small Stresses," Prof. Albert Smith, Purdue University; "Road Building and Inspection," A. P. Melton, Gary, Ind.; "Report on Concrete Roadway at Indiana University," Prof. U. S. Hanna, Bloomington, Ind.; "Standardization of Gravel for Concrete," C. C. Brown, Indianapolis; Reports of committees—Surveying, drainage, roads and pavements, legislation, bridges, mining, water-works, stream pollution; "One Hundred Years' Progress in Public Health Administration," Dr. W. F. King, assistant state health commissioner of Indiana; "The Sanitation of the Panama Canal," Surgeon-General W. C. Gorgas, U. S. A.; "One Hundred Years' Progress in Water-Supply," W. G. Ulrich, Indianapolis Water Co.; "One Hundred Years' Progress in Engineering," Prof. W. K. Hatt, Lafayette, Ind.; Report of Committee on Appraisal, H. O. Garman, Indianapolis; "Efficiency in the Utility Plant," Charles Brossman, Indianapolis; "Municipal Ownership, Yes or No," F. F. Chandler, Chandler & Taylor Co., Indianapolis; "Method of Measuring Consumers' Electric Demand," E. T. Selig, United Gas and Electric Engineering Corporation, New York City; "Handling Coal by the Car-Dump Method," Scott W. Linn, president, the Cavanaugh-Linn Co., Cleveland, Ohio; "Efficiency of Hand-Fired Furnaces," E. B. Smith, Marion Machine and Foundry Co., Marion, Ind.; report of Committee on Sewage Disposal, R. B. Wiley, Lafayette, Ind.; "Sewage Treatment by the Activated Sludge Process," T. Chalkley Hatton, chief engineer, Milwaukee Sewage Commission; "Tax Reform in Indiana," Eben H. Wolcott, state tax commissioner of Indiana; "The Present Status of Water Purification by Rapid Sand Filters," Philip Burgess, Burgess & Long, Columbus, Ohio; "Difficulties of Commission Regulation of Public Utilities," H. O. Garman, chief engineer, Indiana Public Service Commission; "Tests of Concrete with an Admixture of Hydrated Lime," Prof. H. H. Schofield, Purdue University; "Traffic-Study Data," Prof. D. D. Ewing, Purdue University; "Bituminous Mastic Fillers for Block Pavements," J. S. Crandall, engineer, Barrett Manufacturing Co., Chicago, Ill.; "Testing High-Voltage Insulators," Prof. C. F. Harding, Purdue University; "Routing—Its Significance," Asst. Prof. L. W. Wallace, Purdue University; reports—Electrical engineering, central station light and power, electric railroads, steam railroads, mechanical engineering, architecture, reinforced-concrete buildings, masonry and concrete in mass, materials of construction.

TRADE CATALOGS

Joseph Dixon Crucible Co., Jersey City, N. J. Booklet. "Graphite for the Boiler." Illustrated, 24 pp., 3½x6 in.

The John H. McGowan Co., Cincinnati, Ohio. Bulletin No. 40. Deep well pumping equipment. Illustrated, 32 pp., 6x9 in.

Richardson Scale Co., Passaic, N. J. Bullein No. 101. "Automatic Weighing of Coal and Water in Power Plants." Illustrated, 64 pp., 8x11 in.

Mark Mfg. Co., Chicago, Ill. Catalog No. 12. Wrought pipe, boiler tubes, unions, pipe cutters, well casing, etc. Illustrated, 184 pp., 5x7½ in.

Allis-Chalmers Mfg. So., Milwaukee, Wis. Bulletin No. 1632A. Centrifugal pumps and centrifugal pumping units. Illustrated, 46 pp., 8x10½ in.

General Electric Co., Schenectady, N. Y. Bulletin No. 43,253. Series luminous arc lamps. Illustrated, 16 pp., 8x10½ in. Bulletin No. 42,206. Curtis steam turbine generators. Illustrated, 40 pp., 8x10½ in.

Electric Storage Battery Co., Philadelphia, Penn. Handbook FL. "Hyray-Exide" battery for isolated electric plants. Illustrated, 20 pp., 6x9 in. Handbook HX. "Hyray-Exide" battery and switchboard units for small electric plants. Illustrated, 8 pp., 6x9 in.

BUSINESS ITEMS

Maynard D. Church has been appointed chief engineer of the Terry Steam Turbine Co., Hartford, Conn.

Mr. Fred Sutherland has been appointed Chicago manager of the Foster Engineering Co., Newark, N. J., succeeding R. D. Bliss.

The Ohio Injector Co., Wadsworth, Ohio, due to the steady demand for "O. I. Co." products is enjoying good business and closed the year 1915 by filling a carload order for injectors.

The American Rotary Power Co., Westerly, R. I., are preparing to run a series of tests of stuffing-box packing. This is for use on revolving shafts at high pressure and they would be glad to hear from makers of packing which is suitable for such service.

The combined open feed-water heater and hot-water meter known as the Cochrane metering heater, exhibited at the Panama-Pacific Exposition by the Harrison Safety Boiler Works, 17th St. and Allegheny Ave., Philadelphia, has received the gold medal award.

An important change in the sales organization of the Diamond Power Specialty Co., Detroit, is the appointment of Mr. Robert Porter as district sales manager of the Boston, Mass., district with offices at 123 Oliver St., Boston. Mr. Porter was formerly in charge of the Providence agency for this company. Mr. Porter succeeds Mr. Fred Goldthwait.

In view of the great increase in the sales of steam traps Sarco and temperature regulators Sarco, which have broken all records during 1915, a new company entitled the Sarco Co., Inc., has been formed by the Sarco Engineering Co. and the Roller-Smith Co., of New York City and Bethlehem, Penn. The Sarco Co., Inc., which will handle all sales, will control greatly increased selling and manufacturing facilities. It started operations on Jan. 1 and its address is South Ferry Building, New York City.

The prize article contest which is now being conducted by the Diamond Power Specialty Co., of Detroit, Mich., is attracting engineers in all parts of the United States and Canada; $100 in gold has been offered for the four best articles on the subject of mechanical soot blowing. Although the contest does not close until Mar. 1, a number of articles have already been received from interested engineers. The contest is open only to consulting and operating engineers, and to engineers-in-charge. Full particulars relative to subjects, length of articles, etc., may be had by addressing the prize article division, Diamond Power Specialty Co., Detroit, Mich.

The plant of the Ames Iron Works has been operating for several months past far beyond its capacity, both in its boiler and engine departments. Recent sales of the Ames-Stumph Una-Flow engines include: Oliver Iron Mining Co., Duluth, Minn., three 80 hp., one 200 hp.; Ingersoll-Rand Co., Painted Post, N. Y., two 350 hp., two 500 hp.; John T. Thropp & Sons Co., Trenton, N. J., one 400 hp.; Warren Manufacturing Co., Milford, N. J., one 400 hp.; Ajax-Grieb Rubber Co., Trenton, N. J., two 800 hp.; Sibley, Lindsay & Curr Co., Rochester, N. Y., one 250 hp.; Schaefer Brewing Co., Brooklyn, N. Y., one 350 hp., one 175 hp.; American Sheet and Tin Plate Co., New Castle, Penn., one 100 hp.; Standard Wall Paper Co., Hudson Falls, N. Y., one 250 hp.